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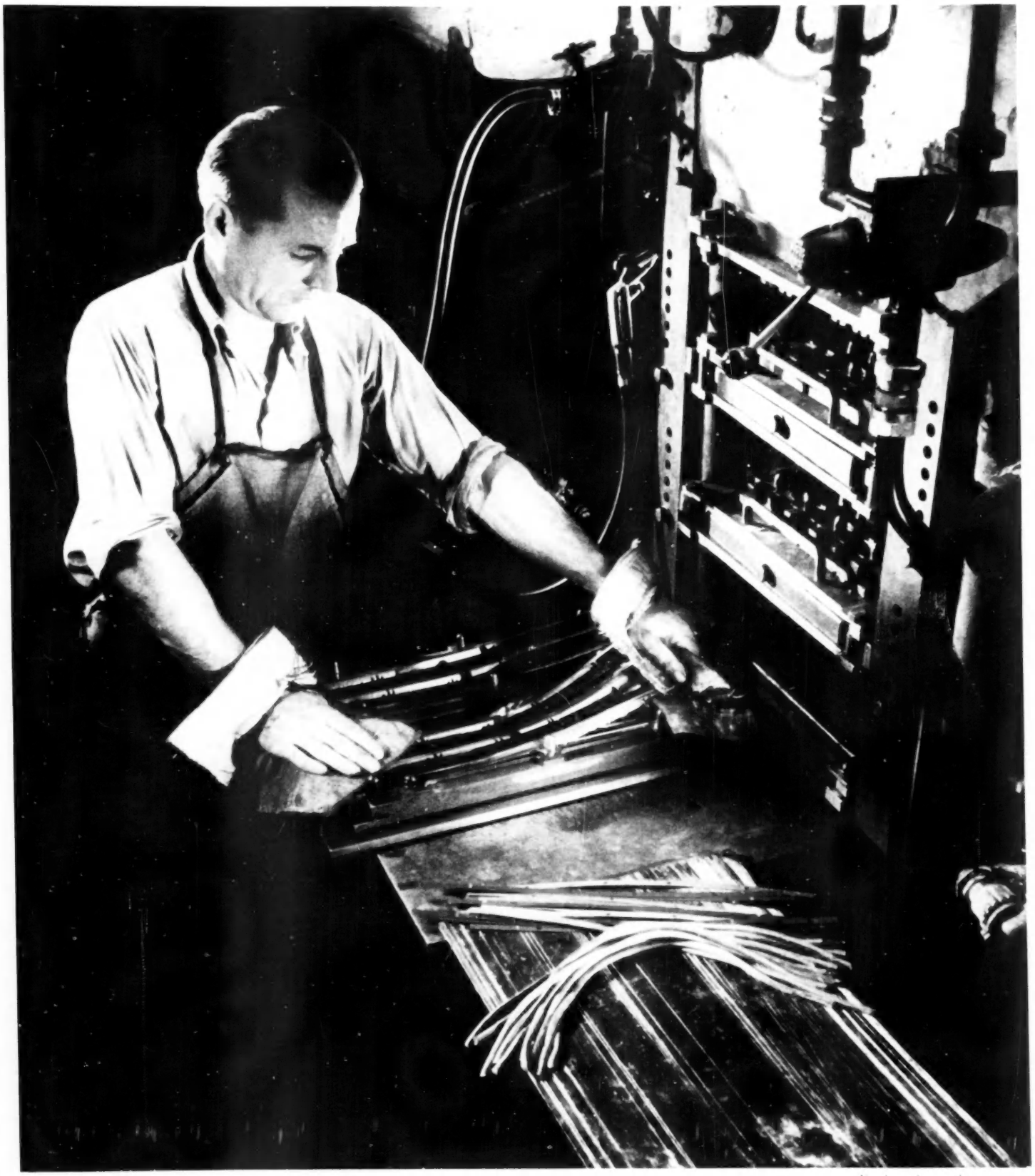

MOULDING IN RUBBER AND METAL

Nurnberg photograph for ENGINEERING

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ENGINEERING

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IMPACT AND IMPULSE

IF any of us could achieve as much influence on public affairs after a lifetime of endeavour as the Soviet satellite has achieved in a few weeks moving unassailably in its orbit, we could look back on a full life and reasonably expect a high honour from our country. By the time it ends its meteoric career in sudden meteoric death, it will have bestirred the West as no statesman has done in the past ten years. The famous unconditional surrender warning to the Germans towards the end of the war is said to have intensified the bitterness of the struggle and rallied the Germans to renewed efforts. In like manner the Russians may one day rue the day when they launch the first man-made satellite, for the full consequences of its effect on the West have yet to be seen.

The Press in this country is an extraordinarily sensitive barometer of public interests and opinions. With only an hour or two to decide the significance of an event which was quite outside any previous experience, the daily newspapers matched the satellite itself in speed of action. One of the difficulties which the Press faced in the first few days was the problem of what to call the thing, especially in headlines. "Satellite" is rather a long word for the convenience of the popular Press. We have constructed a table showing the words used by all the principal London and provincial newspapers during the first week of the satellite's progress. The quality newspapers, as would be expected, were reasonably constant in their use of the proper word. They might use the Russian word *sputnik*, or quote a special word that someone else had used, but normally they stuck to "satellite." The big-circulation dailies, however, experimented with many words. One issue of one well-known paper contained the following: bleep, space satellite, moon, red moon, artificial moon, comet, and red star. Other words that have been tried are: various qualifications of satellite, such as man-made, earth, etc., and then words like baby moon, moon baby, sphere, spinner, little moon, Soviet orb (the last two in American papers), and a whole host of descriptive phrases like tiny bright metal globe, tiny sphere, the thing in the sky, and even "man's first space ship." Of all these words the one which might stay with us, and not without reason, is Bleep. It is derived from the sound that millions of people heard on their television and radio sets as the satellite sent out signals from space; it is a name which will distinguish it from other later and less distinguished satellites (there is always something special about the first-born); and it is a friendly, cosy word.

Fear should have no place among our reactions to the Bleep, though undoubtedly it has affected many people in this way. Far better to feel that this term we have dropped to second or third place in the class, and that next term we can regain first place. Fleet Street is therefore performing a valuable service in cultivating, in the public mind, the belief that the satellite is not a frightening mystery but in principle a simple achievement. It is propelled by the sublimely elemental mechanics of the solar system and every schoolboy can understand the physics behind it.

Attempts have been made, by people who should know better, to discredit the Soviet achievement. It has even been said that the Bleep has no military significance. But anyone with a technical background and a little imagination has no difficulty in visualising the developments which may now take place much more rapidly than was thought possible a few weeks ago. Some of the potentialities are reviewed in a special report on page 484. In this issue, also, is the last of Mr. Ward's reports on the quality of Soviet engineers, based on his recent visit to the U.S.S.R. He will be contributing some further articles on special aspects of Soviet engineering, but the conclusions he puts forward in the current article are highly relevant to the effect of the Bleep on the West. There is to-day an exceptional opportunity for engineers, industrialists, teachers, and all who have a lively appreciation of the revolution that is needed in education, to make their influence felt in committees, Government circles and every centre of authority on these matters. Parliament re-assembles on October 29; by that time the dust should have settled and, with luck, the minimum of time will be wasted on useless argument. Education is a long-term business; half a generation or more is needed for the full value of stepped-up plans to be gained. The increased demand for more engineers and scientists was already well known to the Government committee which reported on the subject in a White Paper published last year. Each industry had estimated its probable demands for several years hence. But even if these demands are still valid—and they are more likely to be underestimates—there is no assurance yet that the schools, universities and technical colleges will be equal to the demands which will be made on them. The impact of the Bleep on the West was suddenly applied, but it is also a continuing impact. The impulse generated in the democracies will gain strength rapidly in the coming months. Here, at last, is the golden opportunity to press home the lessons of scientfic and engineering education.

Cover Picture. *The use of rubber in engineering is constantly increasing. The illustration shows vulcanised sealing strips for use in motor cars being taken from the moulds. The compounds used in the manufacture of such components have to conform to rigid requirements with regard to ageing, staining, resilience, etc., and great care has to be taken to avoid damage occurring to the tools which would cause surface blemishes.*

* * *

Plain Words

The principal hazard created by the recent incident at Windscale is not from radioactivity but from public opinion. As if in a fit of pique at the space devoted to its rival for the scientific headlines, atomic energy has taken violent steps to recapture its pre-eminence. Doubts have been implanted in anxious minds, and a weapon has been forged for the recalcitrant opponents of technical advance. Fortunately, the doubts are ill-founded; but the danger from fear is likely to be formidable.

Overheating of certain fuel elements in one of the Windscale plutonium producing reactors has led to oxidation and escape of radioactive particles into the atmosphere. Within a small radius of the plant, cows have been "quarantined" and their milk, which has been found to have a radioactive iodine content considerably above the permissible, has been destroyed.

Four nuclear power stations are already under construction in the United Kingdom, and on them and their successors Britain's industrial future is likely to depend. Opposition to the choice of site has in each case been encountered. Now the opponents of nuclear power have a weapon which, though it has no edge, may strike some heavy blows.

There is in fact an essential difference between a power-station reactor and reactor such as those at Windscale, designed simply for plutonium production. The reactors at Windscale are air cooled and heat goes up the chimney, carried by the gas. At Calder Hall and in all power stations the heat is used for power production; the coolant gas is contained in a closed circuit and any radioactive products picked up by the coolant cannot escape to atmosphere. Such reactors will be so constructed that precautions will be the responsibility of the designer, not the operator—known as built-in safety.

Serious though the accident at Windscale may be, it must not be allowed to hinder the atomic power programme—except in as much as the lessons learned from it shall be incorporated in new designs. A committee including Sir William Penney, Dr. B. F. J. Schonland, Professor J. M. Kay and Professor J. Diamond has been set up to investigate the matter. The Atomic Energy Authority has a magnificent record; it must not be unduly penalised for one mistake among so many successes, though to state there is no danger when a slight hazard does in fact exist is surely to weaken public confidence. Neither must Britain suffer. It is up to everyone with technical knowledge to explain the reality of the situation to the less informed. The public must be enlisted on the country's side.

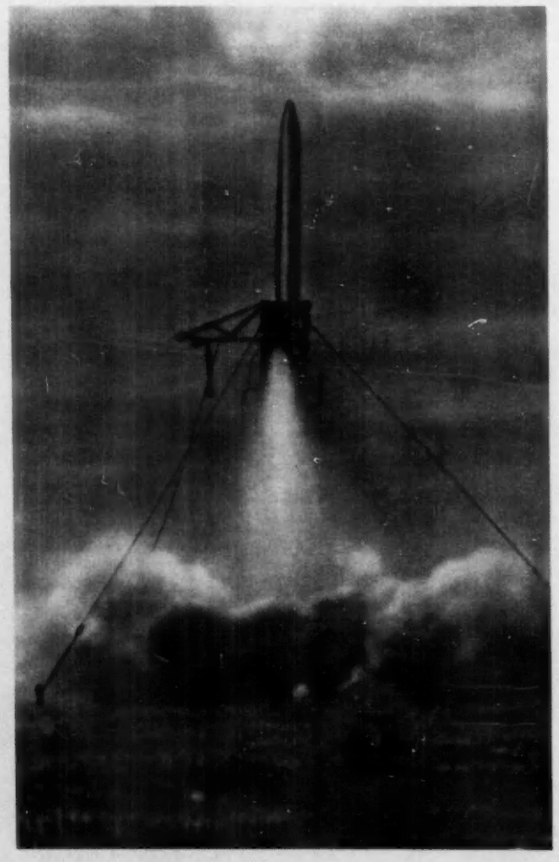
HOW GOOD ARE SOVIET ENGINEERS? *A Summary*

The last article in the present series on the quality of Soviet engineers gathers together and discusses the impressions recorded in the first five. The earlier articles considered the Soviet engineer and his environment, his sources of information, his skill as a designer, the way he runs a factory, and his approach to management. The series has been prepared by Mr. E. P. Ward, M.A., A.M.I.Mech.E., on the basis of a recent visit to the Soviet Union. Although this is the last article devoted to the subject "How Good Are Soviet Engineers?" there will be further articles dealing with equipment, ideas and other features of current Soviet engineering, which will be published from time to time.

WHEN I set out to write these reports, I hoped at the end to have an answer to the question: How good are Soviet engineers? But the answer proves to be more elusive than I supposed. Are they better than British engineers? Are they worse? Are they about the same? Too positive an answer would only betray uncertainty, so I propose in this last article, rather than state an unconditional point of view, to gather my various impressions together, and trust that a valid conclusion emerges.

During the six weeks in which these articles have been appearing, the West has been forced to make an agonising reappraisal of Soviet technical ability; the evidence had long existed, but never before in such a striking form. Now there is a temptation to reassure ourselves, to belittle the talent of Soviet engineers, to suggest that though they are legion, though they can launch satellites, build modern airliners, make high-precision tools, their achievements are ephemeral, a temporary aberration in the irrevocable laws of nature. An uncritical admiration would be equally misleading. It may be more profitable to adopt the Marxist point of view and to assume that in the long run the individual is the product of his environment, that no nation has more innate engineering talent than another, and that engineers are only as good as their education and institutions will allow. Thus, by examining these institutions we may judge the engineers themselves.

First, I should like to discuss what I believe to be a misconception. Soviet society, as distinct from our own, is often regarded as doctrinaire, so that industry is hampered continuously by a ball and chain of political theory. It seems apparent that this is no longer true, that, if anything, Britain suffers more from theory than the Soviet Union. Here I am not concerned to argue which is the more congenial society to live in, only to ascertain which is more likely to be technically successful. The doctrine that the general good follows when management, consumers, workers, unions, shareholders and government all pursue their separate interests has a far more academic, even obscurantist, air than Soviet down-to-earth empiricism. In Russia a nameless official names an objective and the rest get on with the job. Within this framework, the Soviet engineer looks at the facts and acts accordingly; given a target he works towards it unhindered by doctrine or demarcation wrangles on the shop floor. He may pay lip service to Marxism—in assessing production costs, for example—but when it comes to practice he will depend on common sense—labour costs, materials costs, something for plant depreciation, plus three per cent.



Launching an experimental Soviet rocket. Dogs carried to heights of 50 miles have returned safely to earth. The launching of a satellite has created new respect for Soviet engineering.

Even overall planning is subject to empirical criticism. As Academician P. I. Kapitsa told me, everything depends on the quality of the plan. If one approach is unsuccessful, the Soviet authorities will try another. Thus, Mr. Krushchev has introduced his 106 economic regions to overcome the unwieldiness of centralised direction, and Communist equality was long ago abandoned for wage differentials more pronounced than in Britain. I believe that if they found a competitive economy to be the most expedient they would still call it Communism.

At present there is considerable emphasis on systematic organisation—operational research is roughly our equivalent. Kapitsa considered that the speed of technical progress in the Soviet Union stemmed from its planned economy, and that with the new techniques of data processing a planned society would have an even greater advantage over societies that were not. One other, perhaps more fundamental, reason for Soviet success is the tremendous sacrifice made in the past by the Soviet people: by starving themselves of consumer goods in Stalin's era they have built a formidable capital industry. To compete with them we may have

to discover new mechanisms of investment, whereby a greater proportion of our resources than at present are devoted to the future. Singleness of purpose, simplification, standardisation, and the rapid and systematic dissemination of new methods and ideas by research bodies are other potential advantages of a planned and integrated industrial system. I was also told that by means of planning, waste of resources could be minimised.

On the other hand, it appeared to me that there is a tendency for waste to occur in the Soviet Union as a result of imprecise costing—two-thirds empty aircraft illustrate this contention. Planning may also lead to petrification and to insufficient technical intercourse between user and designer. It promotes a problem-solving attitude and leaves little freedom for creative growth. Vladimir Dudintsev, the author

Petrushka. The Russian is not invariably austere, and toys and puppets are often of first-class workmanship. However Petrushka's arms are set, he assumes a characteristically human attitude. He is well finished and strongly made.

of *Not by Bread Alone*, is clearly familiar with the resistance of Soviet officialdom to new ideas; although the automatic drainpipe-making machine invented by his hero, Lopatkin, is adopted in the end, the struggle for recognition is long and arduous. New ideas which accord with an established engineering programme may be adopted; but a significant invention—or a new material—that requires complete readjustment of a five-year plan is likely to be rejected. This is not to suppose that the Russian is any less inventive than his fellows; the deficiency is rather in the mechanism to exploit invention than the man.

The converse is shown by a recent Soviet statement, made in the same week that an article in the present series asked: Can the Soviet engineer change course in midstream? The sixth five-year plan now in its second year is to be replaced in 1959 by a new plan lasting, perhaps, as long as seven years. The revision was attributed to the discovery of " new large deposits of various raw materials and sources of power." A five-year plan may become a strait jacket—though for a foreign exporter it can afford a useful advance guide to marketable products.

In earlier articles, reference has been made to the imitation of Western designs. It should be emphasised that not only is this common practice among countries anxious to catch up or overtake their rivals, but it is also extremely difficult. The man who builds a copy of a modern gear generator needs to know almost as much about it as the man who designed it in the first place. It is reported, too, that some Soviet copies of Western equipment have higher performances than the originals.

In the application of new techniques the Soviet engineer does not appear to lag. Spark-erosion machines are already in production; ceramic cutting tools are in the later stages of development, if not in general use; the flux-bath welding technique has already been applied to the fabrication of large forging presses. Underground gasification of coal operated in conjunction with gas turbines is now established practice. The ZIL automatic foundry is well equipped with modern moulding plant, and the design and development of electronic control equipment for machine tools seems well advanced. Flow-line production is being studied for many different products.

The Soviet Union is almost certainly pre-eminent in the field of applied research. Such research and the vast sums of money devoted to it may, in fact, be the key to current technical successes. Even the research institutes of the Academy of Sciences, which is closer to our Department of Scientific and Industrial Research than to our Royal Society, keep their eye on the ball, developing oil-refining plant, electrical equipment and advanced machine tools. The pure research of string and cocoa tins seems to have little place in the Soviet system. There may, however, be some overlapping between the institutes of the Academy of Sciences and the branch or industrial institutes; I saw two similar but distinct designs of spark-erosion tool, one in the pavilion of the Academy of Sciences at the permanent industrial exhibition, and one in the catalogues of Enims, the machine-tool research institute.

The branch institutes are the instruments of industrial power. Not only do they carry out research, but they are responsible for the distribution of information and the preparation of quota recommendations for submission to the state planning commission.

Though not the real seat of Soviet technical education, Moscow's university is a symbol of the high place that education occupies in Soviet life. Diploma engineers are trained in polytechnic institutes in great numbers but are not always fully used.

The dissemination of data and ideas is clearly another major factor in Soviet progress. New techniques are systematically communicated from one factory to another and the work of the Central Institute of Scientific Information in condensing, abstracting and translation provides an easily assimilable source of up-to-date information. It is significant in this context that, in the West, firms have been known to conceal technical problems (which might easily have been solved by a responsible research institute) in the interest of sales policy. In the West it is common for research institutes to be staffed by young graduates who will later escape to industry; whereas in the Soviet Union practical experience is a prerequisite of entry into research work. But in Russia, as elsewhere, research institutes receive more orders than they can tackle.

Another aspect of Soviet policy which has yielded startling results is the concentration of resources on selected projects. Jet engines, rocket research, housing schemes, electricity supply, tractor production, and transport are sectors of engineering that have undergone this treatment. The scope of such programmes may be gathered from the fact that apartments for 300,000 families are under construction in Moscow alone. Frequently, they are based on research " commandos " with staff drawn from all relevant branches of science and engineering.

It should be borne in mind, however, that

After the Tupolev Tu104 comes the propeller turbine Tu110. A four-engined high-wing airliner, the Ukraina, has also been built. Great resources have been devoted by the Soviet Union to the development of a modern aircraft industry.

these tactics are only suitable for countries which are generally backward, since otherwise resources are likely to be spread over a wider range of projects. In addition, they are wasteful since their purpose is to concentrate *at least* enough resources on the project to ensure success. An example of this wastefulness may be the 10 GeV synchrophasatron at Dubna, which requires 36,000 tons of magnet steel and when operating consumes 144 MW of electricity. With strong-focusing—a principle devised since the 10 GeV machine was designed—the same result could have been obtained with a fraction of the steel and hence at a fraction of the cost. This may have been a case of too much haste. Thirdly, these tactics overlook the advantage of integrated technical development on a broad front, where discoveries in one field are likely to be of assistance to another. Nevertheless, in the Soviet Union, the number of parallel task projects is sufficiently great to approach this ideal.

Probably the most widely publicised of the Soviet Union's resources is the enormous reserve of qualified engineers. Indeed, reserve is the right word, for they are as yet not fully put to use. At most of the factories I visited there was a considerably higher percentage of engineers than would appear to be necessary for efficient operation; thus Soviet productivity in machine-tool manufacture appears to be slightly lower than in this country, but the proportion of engineers in the Soviet machine-tool industry seems to be much higher. In addition, although the British electrical industry, with some 700,000 employees, is known to be among the most efficient in the world there are only 34,700 members, associate members or graduates of the Institution of Electrical Engineers (5 per cent.), whereas the Soviet figure for diploma engineers in the electrical industry is nearer 15 per cent. This comparison is, of course, subject to considerable error; many mechanical engineers are employed in the British electrical industry, though many electrical engineers are also employed outside it; the equivalence of institution membership and diploma engineer is by no means established. Nevertheless, the figures give some indication. It is of relative interest that whereas Britain produced steam turbines with a total output of 3,540 MW in 1956, the comparable Soviet figure is only a little over 4,000 MW, in spite of a considerably larger population.

The only possible conclusion is that Soviet industry has at present more engineers that it can usefully accommodate. What is the purpose of this excess? It seems likely that they represent a cadre for future expansion. But, although the Soviet Union is nearly 100 times as large as the United Kingdom, it has a population only four times as great. Where, then, is the skilled and unskilled labour to be found to bring these cadres up to strength? There appear to be several possibilities. China and the Soviet Union would represent a formidable partnership if the labour of one were combined with the experience and engineers of the other. Secondly, there is automation, which is in fact, the subject of a current large-scale research and development drive. The supposedly limitless manpower resources in the Soviet Union are thus shown to be a fiction.

Something has been said in earlier articles about the widespread use of female labour in the Soviet Union—a reserve which in this country is largely untapped, and is likely to remain so. Thus, whereas at the Electrosila plant 52 per cent. of the 6,000 employees are women, only one-sixth (3,607) of the 21,673 employees at the three main factories of the Metropolitan-Vickers Electrical Company, one of our largest and most efficient firms, are women. Incidentally, the proportion of workers on straight piecework at Metropolitan-Vickers is 54 per cent., rather less than at the Soviet factories I visited, illustrates perhaps the trend away from piecework in this country, though, of course, the British company and most of the Russian factories have additional bonus schemes.

It is also of interest that although the employees of Metropolitan-Vickers have similar social and recreational facilities to those at the Soviet factories, the British club houses, theatres and playing fields are owned and administered by the employees themselves. Metropolitan-Vickers support these organisations by large grants, but exert no control—a rather more democratic procedure than in Soviet industry. I saw no evidence at any Soviet factory of apprentice workshops and training schools on a scale comparable to those at Metropolitan-Vickers, though, of course, the educational facilities of this company are known to be exceptional.

What seemed to me the most fundamental difference between East and West lay in the Soviet neglect of advertising. In the West, advertising creates a climate of emulation and endeavour, which is to a great extent lacking in the Soviet Union. If a woman is persuaded by every placard that life without a television set or a sewing machine is insupportable, her husband may be spurred to greater efforts in order to secure these necessities for her. The perhaps excessive care that Western women—and men—devote to their appearance is a product of advertising almost unknown East of the Oder. At the extremes there is a neurotic urgency in the West, and lethargy in the East; or, put less dramatically, the American has drive and the Russian is stolid and relaxed—both conditions have their advantages.

There are many ways in which the approaches of East and West differ, with merits and defects distributed almost equally. The tendency in the Soviet Union for capital to be effectively written off once it is disbursed, brings waste in certain activities—airline operation for example—and benefits in others. Planning may guide activity but hinder the exploitation of invention. Interchange of information between factories prevents duplicated effort, but undermines the fruitful impulse to compete. Soviet engineers have achieved great successes by directing immense resources to selected projects, but mass procedures may lead to faulty costing and consequently waste.

Yet in many ways, Soviet engineering and our own are very similar. The theory may be different but the practice is much the same. Both groups of engineers are fundamentally sensible people, and their solutions to problems of design are often so alike as to be scarcely distinguishable. Both believe in order, though only one would call it planning. Indeed planning is effectively administered at the same level in both hemispheres. The Soviet industrial research institutes are intermediate between government and people, as are the large companies in this country—effective planning comes therefore from the middle.

The essential difference is largely philosophical. The Russian feels that it is more dignified for mankind to determine its own destiny than to be constantly subject to the whims of impersonal economic forces. The West, on the other hand, places its faith in the manipulation of these forces on behalf of the individual. East and West are like two civil engineers: one prefers to dynamite the terrain to accord with his design; the other adapts his design to the terrain.

It is in the degree that each recognises the terrain, or the situation, that he is likely to succeed as an engineer. There is no mysterious dynamic in the Soviet system, to give the East an ultimate advantage, except its willingness to sacrifice the comfortable present to the splendid future. It may be that we shall have to follow suit or fall behind. The Soviet engineer is a formidable rival, quick to take advantage of his many opportunities. But he has no magic powers.

HOW GOOD ARE SOVIET ENGINEERS?

Reprints

The series of articles How Good Are Soviet Engineers? is to be reprinted as a booklet. Copies may be ordered from ENGINEERING, 35-36 Bedford-street, London, W.C.2, price 4*s*. (including postage).

PRACTICAL ASPECTS OF EARTH SATELLITES

The successful launching of the first Earth satellite from the U.S.S.R. has demonstrated, in a most dramatic way, that rockets have vast potentialities for extending our knowledge of the solar system, and it is worth enquiring into the energies and accuracies required for present and projected journeys.

Energy Requirements

In many cases, the fraction of energy necessary to overcome the resistance of the Earth's atmosphere may be neglected, since the greatest proportion goes to increase the kinetic and potential energies of the vehicle relative to the Earth's surface. A convenient manner of expressing the energy requirements for a unit mass is by stating the total equivalent velocity change, relative to the Earth's surface, required to perform a particular evolution. This change in velocity is termed the characteristic velocity for the evolution. For a satellite, close to the Earth in a circular orbit, the velocity in the orbit must be such that the outward centrifugal force exactly balances the gravitational attraction, and this, which is the lower limit for any continued flight without the support of the atmosphere, requires the satellite to be given a velocity of 7·9 km./sec. about the Earth. If the satellite be launched from the equator, in an easterly direction, there is a contribution of 0·46 km./sec. from the earth's rotation, but this is not available if the satellite must pass close to the north and south poles.

If the characteristic velocity is increased over the "circular velocity," the vehicle takes up an orbit which, typically, is an ellipse, with its nearest point of approach (perigee) close to the Earth's surface. A particular value of the characteristic velocity corresponds to an ellipse of a particular length of major axis: from 12,800 km. (7,900 miles, the Earth's diameter) at 7·9 km./sec., we go to 18,000 km. at 9 km./sec. and 32,000 km. at 10 km./sec. These orbits all have the same close approach to the Earth, and are distinguished by greater and greater distances of farthest departure from the Earth (apogee). For the same characteristic velocity it is possible to put the vehicle into an orbit which approaches a circle more nearly, but which also has a greater perigee distance and a smaller maximum velocity in its orbit (this has to be done with a satellite intended to stay outside the Earth's atmosphere). If the characteristic be increased to 11·2 km./sec. the trajectory is no longer an ellipse but a parabola: the "escape velocity" is reached. Any increase in characteristic velocity produces a hyperbolic orbit, which becomes more and more nearly a straight line as the velocity approaches infinity.

The return journey to the Moon, without a landing, is a good example of an elliptic satellite orbit with a long major axis. In fact, the characteristic velocity required for this orbit is negligibly different from the Earth's escape

velocity, but to return safely to the Earth's surface, the whole of the satellite velocity must be cancelled by rocket action. The velocity which must be given to the vehicle by the energy stored in its propellant is thus 22·4 km./sec.

As an example of the characteristic velocity required for interplanetary travel, the Earth-Venus single journey may be considered:

	Km./sec.
Escape from Earth	11·2
Transfer from Earth's orbit to journey path	2·5
Transfer from journey path to orbit of Venus	2·7
Landing on Venus	10·4
Characteristic velocity	26·8

Energies Available

The magnitude of the problem is now stated. The possibility of solving it can be discussed in the light of a recent paper by L. R. Shepherd.[1] It must be noted that the performance of a rocket vehicle, in terms of the maximum velocity which can be achieved when all the propellant is expended and in the absence of a gravitational field, depends on the velocity of the exhaust gases relative to the rocket and on the overall mass ratio:

Maximum (characteristic) velocity $= c \log_e \Lambda$, where c is the exhaust velocity, and Λ is the overall mass ratio. Since the logarithm of the mass ratio is involved, high values of the exhaust velocity should be used if the mass ratio is to be kept reasonable. However, even with a very high exhaust velocity, such as is given by a combination of liquid hydrogen and liquid oxygen (3·8 km./sec.), the simplest of our journeys, the close satellite orbit, requires $\log_e \Lambda$ to be 2·64, or $\Lambda = 14$, and this cannot be achieved with single stage rockets. However, by using a number of stages, fired in sequence, the total mass ratio is given by the product of the individual mass ratios. The mass ratio (full mass/empty mass) depends on the structural factor (payload mass/structure mass), but by taking a value of structural factor of 0·1, Dr. Shepherd obtains the figures given in Table I, for the ratio of payload mass to all up mass, which is valid for currently available chemical propellants.

TABLE I.—*Ratio of Payload to Launching Mass, with Number of Stages, for Chemical-Propellant Rocket Vehicles*

Journey and actual characteristic velocity	Exhaust velocity			
	3·8 km. per sec. (liq. H_2/liq. O_2)	3·2 km. per sec. (hydrazine/liq. fluorine)	2·7 km. per sec. (liq. O_2/kerosene)	2·2 km. per sec. (solid propellant)
Earth satellite (10 km./sec.)	0·033 (2)	0·022 (3)	0·0096 (3)	0·0037 (4)
Escape rocket (13·5 km./sec.)	0·012 (3)	0·0060 (4)	0·0019 (4)	4×10^{-4} (5)
One-way moon vehicle (17 km./sec.) ..	0·0042 (4)	0·0012 (4)	3×10^{-4} (5)	6×10^{-5} (6)
Return moon vehicle (25 km./sec.) ..	2×10^{-4} (5)	5×10^{-5} (6)	12×10^{-6} (7)	6×10^{-7}

The figures given in brackets represent the number of stages of equal mass ratio required in the vehicle, assuming them to be similar as regards structure and propellants.

It is apparent that, with reasonable improvements on current designs, a load of 100 kg. of instruments could be placed on the Moon with a vehicle of 100 tons take-off mass, which is perhaps that of the present U.S.S.R. satellite launcher. Also, with conventional chemical propellants and in due course a manned satellite or project instruments could be put up to a virtually infinite distance from the Earth (the Americans are doing something towards this now with their " Project Farside," which aims at getting instruments 4,000 miles from the Earth's surface).

However, for men to go and look at the Moon and return, the payload (men, their transported Earthly environment and instruments) would approach say 20 tons, and, from Table I above, this requires a rocket of about 100,000 tons take-off mass. Since, as noted by Dr. Shepherd, vehicles of this type are liable to cost between £5,000 and £10,000 per ton of launching mass, the bill amounts to £10⁸ or £10⁹ for a single vehicle, which is a lot. Starting the trip from a close satellite orbit would need a smaller long distance vehicle, but there is still the need to ferry the components of this vehicle into the orbit, and this, even allowing for 90 per cent. recovery of the ferry vehicles, means that 10,000 tons of vehicle would be lost. Propellants with much higher exhaust velocities must be developed before such projects become " economic."

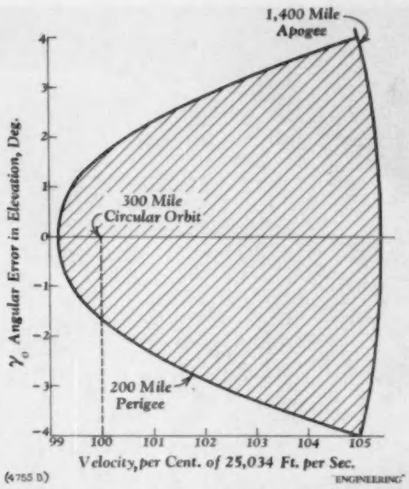


Fig. 1 To put an earth satellite into orbit successfully, close control over errors is necessary. The drawing above shows the interrelation of velocity and angular errors.

The Value of Accuracy

With only limited amounts of energy available, it is imperative that none is wasted in correcting launching errors by navigation later in the trajectory. Also, if an unmanned vehicle is guided inertially (i.e. by integrating accelerometers), it is necessary to ask what errors can be tolerated in guidance if the vehicle is to fulfil its task reasonably satisfactorily. Taking the simple Earth satellite, Milton W. Rosen[2] recently said that, in order to keep the perigee distance of Vanguard at about 200 miles, the orbit being nominally circular at 300 miles, strict limitations had to be imposed on the velocity at the end of the launching period and on the angle of elevation of the trajectory (relative to the Earth's surface immediately below), and that these errors were interrelated (see Fig. 1). If the final orbital velocity at launch were less than 1 per cent. short of the desired value (7·65 km./sec.), the satellite would fall below 200 miles during its first revolution, no matter what the elevation angle were; for 100 per cent. of the launch velocity, approximately $\pm 1\frac{1}{2}$ deg. error could be tolerated, while if the satellite were launched with 105 per cent. of the nominal velocity, $\pm$ 4 deg. error could occur. This excess velocity implies, of course, that the apogee distance becomes great: 105 deg. corresponds to an orbit 1,400 miles above the Earth at apogee.

Turning to more ambitious journeys, Hans A. Lieske[3] of the RAND Corporation has computed the errors permissible for Moon trips. He obtained the following values, using as the nominal initial velocity away from the Earth 10·7 km./sec., at 350 miles:—

To hit the Moon at all	$\pm$ 40 ft./sec., $\pm \frac{1}{4}$ deg.
To hit the Moon within a given circle of 100 miles radius ..	$\pm$ 2 ft./sec., $\pm$ 0·01 deg.
To put the vehicle into an orbit about the Moon with altitude accurate to within 100 miles	$\pm$ 2 ft./sec., $\pm$ 0·01 deg.
To go to the Moon, orbit, and land back on the Earth with 1,000 mile landing uncertainty ..	$\pm$ 1·12 ft./sec., $\pm$ 0·01 deg.

Satellite Uses

An artificial satellite can be used for a variety of purposes. It provides a most valuable instrument for research but in addition it can be put to more utilitarian ends. In research its chief advantages are its situation outside the atmosphere and the fact that it is falling freely. In other applications its value stems from its great height.

RESEARCH

Even an instrumentless satellite provides valuable information about the earth and its atmosphere. The introduction of instruments leads to further reward, while the manned satellite laboratory is the dream of many a research worker.

Astronomy.—Of the wide spectrum of radiation that is presumed to fall on the earth, only a small portion reaches the surface. The remainder is absorbed in the atmosphere. As valuable as this absorption is to life on earth, it is a source of frustration to the astronomer. He is presented with but two small " windows " in the spectrum through which he may study extra-terrestrial systems. The more well-known window, the optical one, is not as clear as an astronomer would desire. Many people will have looked at photographs of Mars and been disappointed by the fuzziness of the reproduction. The irregularities of the atmosphere are to blame for such blurring. Similarly the other window, the one through which radio waves between 2 cm. and 20 m. can pass, is subject to variations in behaviour.

In a satellite, results far superior to those obtained with the 200 in. Mount Palomar telescope could be achieved, using a much smaller instrument. A valuable consideration in the construction of telescopes for satellites is the weightlessness of the parts.

Data collected by a telescope in a satellite would either have to be transmitted by radio to the ground or else photographs would have to be taken and recovered later.

Regions of the spectrum of greatest interest to the astrophysicist are the far ultra-violet (3,000 to 300 Å) and the cosmic ray region. Simple studies can be made in the latter, using counter techniques.

Geosciences.—Geophysics, geology, geomorphology, and meteorology can profit from experiments made with satellites. A magnetometer circling the earth will provide valuable information about the distribution of the magnetic field above the ionosphere. In a proposed Vanguard satellite installation, the magnetometer will weight 3 lb. exclusive of the battery to drive its electronic portion.

The orbit followed by a satellite will also give information on the earth's shape and its gravitational field. During re-entry useful knowledge of the upper atmosphere will be gained. Study of radio propagation from the satellite will furnish information about the ionosphere.

In tracking experiments it is likely that sodium vapour or nitric oxide will be used to mark the path of the satellite. The behaviour of the vapour—its rate and manner of dispersal—will give information on the processes occurring in the upper atmosphere. Such investigations will have an important bearing on theoretical meteorology.

Physical and Chemical.—It is unlikely that early satellites will be concerned with physical or chemical experiments which are unconnected with upper atmosphere of astrophysical research. However, satellites do present the scientist with a new set of conditions for experiments and it is likely that advantage will be taken of them in the future. The exchange processes occurring about the satellite will be of interest. So also will be the study of particles in free space.

The satellite would allow the study of materials and rates of reaction under extreme conditions

of temperature and radiation. By orienting the satellite to present one side to the sun continually, materials could be studied at very high and very low temperatures by placing them at various positions on the satellite.

Biological.—Man certainly wishes to travel in outer space. Whether he is able to do so will depend to a large extent on the reactions of his body to the strange environment. In this respect biological experiments in a satellite will be important.

The behaviour of organisms in free-fall regions must be studied. For instance, the small single-celled creatures such as the amoeba might develop into giants in these regions.

If man is to travel in space, the provision of food supplies becomes very important. For long periods, systems resembling the ecological system of a planet must be developed. The ability to make a long-term study of organisms in a satellite under conditions that cannot be produced in the laboratory is most valuable. Experiments have been made with animals in rockets but the short duration of the flight is a disadvantage.

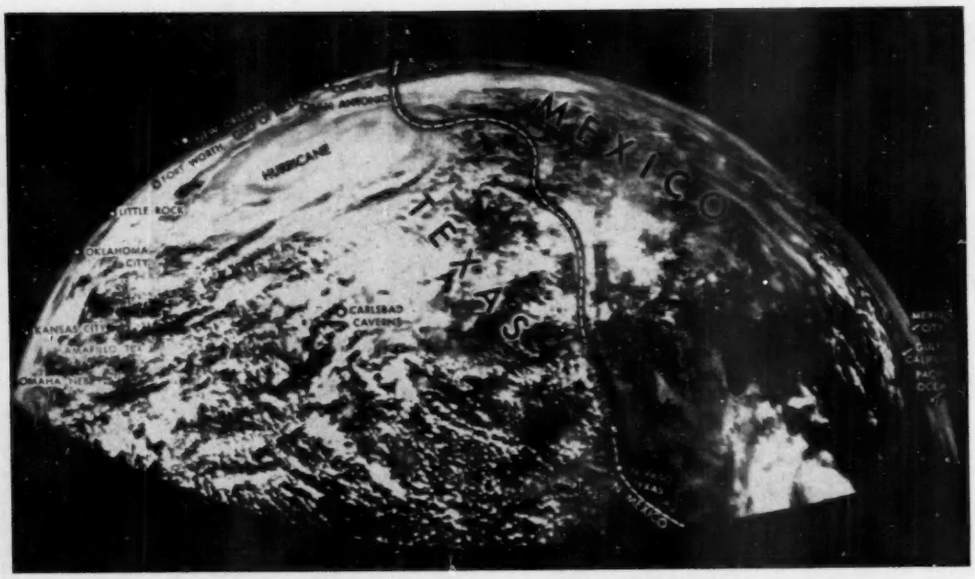


Fig. 2 Satellites could present the meteorologist with a large-scale view of weather conditions. The curvature in this illustration does not correspond to the Earth's.

Solar System Probes.—Many of the previous research applications require the telemetering of data. It is likely, therefore, that telemetering techniques and rocket techniques will advance together and by the time it is feasible to put a satellite into free orbit around the moon it will also be possible to radio back information concerning the conditions encountered there.

Ideally, television will be used, but significant advances will have to be made in the reduction of size and power requirements of such equipment. Practically all electronic equipment and photographic film will suffer from cosmic ray bombardment. This will show as an increase in electrical noise and as tracks in the films.

UTILITARIAN

The great height of a satellite makes it a valuable asset in surveillance of the globe. Various types of satellite are possible depending on the orbit used. It would be possible to have a satellite rapidly encircling the earth in a few hours, or stationary above a particular place on the earth. The orbit selected will depend largely on the particular use for which the satellite is designed.

Observation.—Equipped with a television camera, a satellite can be used for observation of the earth and the lower atmosphere. In the latter respect it can be a valuable tool for the meteorologist. In Fig. 2 is shown the sort of view that a satellite might have. The hurricane near Little Rock can be clearly seen and illustrates the manner in which the weather forecaster will be presented with details of wind and cloud systems.

It has also been suggested that accurate checks on troop movements, shipping and aircraft can be made by a satellite equipped with television. It is likely that such movements could be concealed if sufficient care were taken. However, certain events, such as nuclear tests, would be clearly visible to the satellite.

An observation satellite would also be of value as an iceberg patrol and a thunderstorm warning.

Military.—As the establishment of an earth satellite is largely the result of military research into rockets it is interesting to consider its military aspects. It has great propaganda value since it flies over enemy territory without hindrance. Its observational powers are valuable, too. Although troop movements, etc., can be concealed, the concealment itself is a considerable nuisance and a hamper to mobility.

Naturally, speculation arises as to whether a satellite might be used as a launching platform for nuclear weapons. However, it would be so much cheaper to deliver a nuclear warhead by ballistic missile that this use for a satellite seems unlikely.

Communications.—The value of satellites for communication purposes has been pointed out long ago. Two basic systems are possible. Either the satellite is a simple metal reflector or else it acts as a relay station, having an in-built transmitter and receiver.

Transmitters and receivers on the earth making use of reflections from a satellite would require an automatic tracking mechanism to follow it across the sky. Also three satellites would be required for continuous signalling. With smaller satellites the tracking problems become more difficult and the ground equipment more complex. Introduction of repeater equipment allows ground equipment of a lower power and smaller spheres, but the satellite requires a power supply.

Navigation.—Radio beacons on the earth are always hampered by the fact that they have limited range. A satellite would not have this difficulty. Various types of satellite beacon have been suggested. One project visualises the establishment of a number of satellites on 24 hour equatorial orbits. Each satellite would remain over one point on the earth's surface and be a simple counterpart of the fixed radio beacon. However, the technical difficulties of establishing such an orbit are very great. Any errors in placement would tend to invalidate the simplicity of the navigation system relying on the satellites. Further errors which would require correction would be refraction effects introduced by the atmosphere.

An alternative has been suggested by Mr. L. Lawrence, general supervisor, Missile Operations, Chrysler Corporation, Detroit. In his system, "Astro," he considers three polar orbits of 105 minutes period. A transmitter frequency of 100 Mc/s is suggested and two types of aerial system are considered, one being directional.

The position of an observer on the ground would be fixed by use of an electronic sextant and an almanac; alternatively, a Doppler system could be used. The system would be of advantage where hourly fixes were required under bad visibility conditions that preclude normal celestial navigation.

Mr. Lawrence also gives details of a proposed power source using the heat of radioactivity of strontium 90 yttrium isotopes to power a thermocouple. A diagram of the device is shown in Fig. 3. An efficiency of about 5 per cent. is achieved, which is comparable with the efficiencies of other devices proposed for satellite power generation.

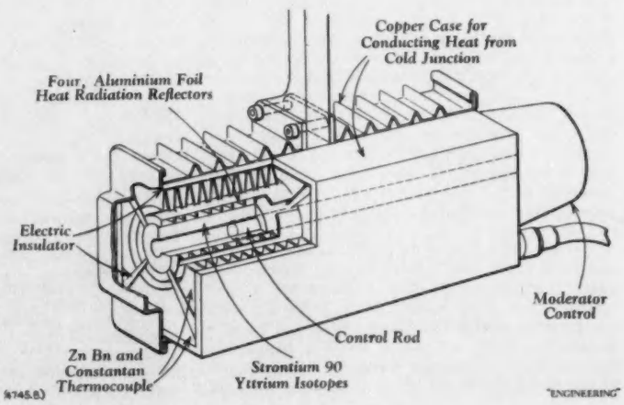


Fig. 3 Power supplies present a problem in satellites carrying instruments. A power generator using a thermocouple and a nuclear heat source is shown.

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[1] Shepherd, L. R. Proceedings of the High Altitude and Satellite Rocket Symposium, held at Cranfield by the College of Aeronautics, the Royal Aeronautical Society, and the British Interplanetary Society, July 18-20, 1957 (to be published).

[2] Rosen, M. W. *Ibid.*

[3] Lieske, H. A. Meeting between Convair and the USAF Office of Scientific Research: paper summarised in Aviation Week, March 4, 1957, **65**, 9.

Companies in the News

Shipbuilding Revival in U.S.

The American Ship Building Company report an order book of approximately 30 million dols., including the current construction of two bulk cargo vessels for the iron trade, the lengthening of two bulk-cargo vessels and the construction of two destroyers. Their president, Mr. Edmund Q. Sylvester, forecasts "steadily improving performance." This is evidence of a revival in United States shipbuilding which is symptomatic of great activity throughout the world. Since the war, American shipowners have placed an immense volume of orders in foreign yards, mainly because capacity was available and costs were relatively low. Now costs outside the States are rising fast, hence the filling up of American yards. Mr. David K. Ludwig's recently placed order in Japan for five oil tankers of 104,500 tons deadweight each suggests that the revival of United States shipbuilding is doomed to be short-term but it should not be overlooked that an increasing number of foreign yards, particularly in Japan, are American owned. The builders of Mr. Ludwig's mammoth tankers will be the Kure shipyard division of his own company, National Bulk Carriers Incorporated. All the construction will be done at the former Japanese naval yard, of which the American company have a lease extending to 1966 with an option to 1971.

These developments—United States investment in yards abroad and the recommissioning of American yards—should be carefully watched by shipbuilders in Britain. The British still have advantages over their competitors, particularly in the supply of skilled labour, in experience and in the availability of cheap steel.

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Customers and Costs

Another pleasant surprise for the investor in these days of gloom has been provided by Serck Radiators. Trading profits have jumped by £307,000 to £1·04 million for the year ended June 30. A significant inclusion in this figure is four months of the profits of the group's new subsidiary, the Audley Engineering Company. Audley Engineering specialises in valves for controlling the flow of liquids and have their principal markets in the oil, chemical and gas industries. The significance of Audley's inclusion lies in the evidence it provides of a policy of wide diversification of Serck Radiators' interests which has considerably diminished their dependence on the motor industry. They supply manufacturers of aircraft, locomotives, ships and heavy electrical machines as well as vehicles.

Qualcast's fortunes in the year ended June 30 are much more typical of the better-than-average engineering firm heavily dependent on the motor industry. Their profits for the year fell from just over £1 million to £749,000. Mr. J. E. V. Jobson, chairman and managing director, was able to refer to his last year's speech in which he predicted lower profits. His reasons for this will interest many engineering companies, since few companies range as widely over the engineering industry as a whole. The main contributory items were: (*a*) foundry raw materials greatly increased in price, particularly pig iron; (*b*) together, the foundry differential and the engineering wage awards increased costs considerably; (*c*) the recession in the automobile trade cut back foundry output very severely; and (*d*) the engineering strike caused the close-down at one period of 2½ factories.

The picture painted by Mr. Jobson has implications for industry as a whole which are anything but good. The falling rate of profit threatens growth, and this is a serious matter. Another threat to growth is the lack of incentives for those who determine it: "To-day," he said, "we live in an era where incentives for the top men, those who create the wealth in which we all share, are inadequate, yet the penalties for failure are as stern as ever they were."

★ ★ ★

Ford and Renault

The half year's results of the Ford Motor Company have taken observers by surprise. Sales for the six months ended June 30 totalled £79·9 million, higher than in the corresponding period of 1955. Profits on trading amounted to £9·16 million (11·5 per cent.), lower than in the first half of 1955 (£11·38 million or 14·5 per cent.) but higher than either in the second half of last year (£4·36 million) or in the first half (£5·63 million). The company would appear to be well set for a record year, surpassing even the automobile boom year of 1955. Nothing published gives even a first assessment of the likely impact of the Government's latest wave of credit restriction. At present the motor industry is working to full capacity or very near it. It is unlikely, however, that the same contrast will be as apparent with most of them as with Ford. They were probably hit harder by petrol rationing and have experienced a demand for their 1957 models higher than most firms. For the industry as a whole production in the second quarter was about 45 per cent. higher than in the first, and only in May and June did it reach the present full-capacity level.

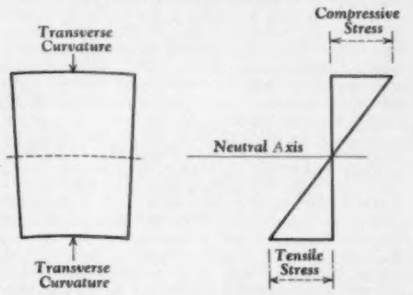
The annual report of the Régie Nationale des Usines Renault, published last week, shows that the motor industry of France has made good strides in the past two years. In 1955 output increased by over 26 per cent.; last year the rise was 18 per cent. The daily output of 1,400 vehicles was 24 per cent. higher than the average in 1955. An export figure of nearly 28 per cent. represents a major advance and illustrates the popularity of the elegant and tough Dauphine, particularly in the United States.

Letters to the Editor

"THE FULL PLASTIC MOMENT"

SIR, There have recently been published a number of text-books and frequent papers on the plastic design of structures, where one of the basic criteria is the "full plastic moment" of the structural members that is evidently equivalent to the modulus of rupture (or modulus of yield of ductile materials) multiplied by the section modulus.

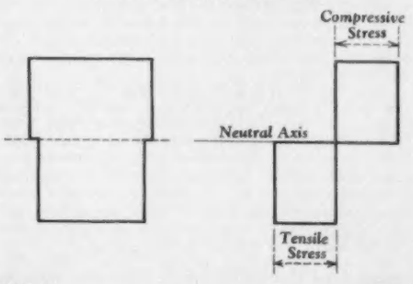
Examining bodies have now introduced the plastic theory and design of structures into their syllabus of examinations, so that the rising generation of engineers is about to be introduced to the "full plastic moment." The usual assumptions relating to frictionless fibres, etc., used in the elastic theory of bending, are to be retained and in addition the students are asked to believe that when the "full plastic moment" is developed: (1) the materials have become plastic (2) the compression and tension stress diagrams are rectangular, reverting to the Problem of Galileo, but now the maximum stresses are assumed to act simultaneously at the neutral axes of the members. The assumptions are not to be supported by any direct factual data, although they may be said to be somewhere between the catagories "highly theoretical" and "quite improbable."



Theoretical distortion of a rectangular cross-section, confirmed by experiment.

Theoretical stress distribution up to the proportional limit, confirmed by experiment.

Elastic Theory of Bending



Theoretical distortion of a rectangular cross-section, not confirmed by experiment.

Theoretical stress distribution at "full plastic moment," not confirmed by experiment.

Plastic Theory of Bending

The "full plastic moment" of a solid rectangular section is based on a section modulus of $\frac{\text{breadth} \times \text{depth}^2}{4}$ giving a modulus of rupture 50 per cent. greater than the elastic theory, but it is often found that test results on rectangular sections of some materials have considerably higher values, and for some sections appreciably less. In order to forestall awkward questions, when the modulus of rupture exceeds the "full plastic moment," demonstrators might suggest that the materials have passed from the "plastic" to the "atomic" state and are liable to disintegrate—the last part being probable, but this contemporary explanation probably would not convince the modern student.

There must be very good reasons why the strength in bending of solid bars of ordinary materials usually exceeds the theoretical elastic and plastic moments and it is suggested that the true reasons should be properly verified, before the "bending paradox"—so named 100 years ago by Professor P. Barlow—is explained to the present generation of students.

In the writer's opinion a more probable explanation may be found by applying to the problem well-known Newtonial principles and scientific methods of research, so that it is along this route that engineers and students may eventually arrive at satisfactory conclusions that will be able to explain other experimental anomalies, not in accordance with the present theories.

Yours faithfully,

A. N. PROCTER.

528 Beechdale-road,
Western Boulevard,
Nottingham.
October 8, 1957.

DESIGN OF HAND HAMMERS

SIR, You publish a very interesting article by Mr. A. H. Burn on "Chipping of Hand Hammers in Service" in your issue of July 12 (page 48), to which I should like to refer.

I am not a metallurgist or in any other way qualified to join in a discussion on the subject,

Continuing Letters to the Editor

except, perhaps, as an occasional user of hammers, and as such I am of the opinion that the problems could also be tackled from the design aspect, and not from the metallurgical point of view only.

It is obviously quite impossible for the average user to hit an object dead square every time, and it is the occasional impact on the edge of the striking face, due to the length axis of the hammer being slightly inclined to the line of travel at the moment of impact, which causes the chipping. The remedy is quite obvious, i.e., to give the striking face of the hammer a pronounced spherical surface, with a radius of, say, 9 in. or less, instead of leaving it flat.

A further modification in the design of hammers, which, in my opinion, would increase the chances of hitting squarely, would be to bring the centre of gravity of the hammer head very much nearer, perhaps right into, the centre of the hole. This " balancing " of the hammer, incidentally, would make work less tiring on those occasions when the hammer has to be swung in a horizontal plane, as, for instance, when knocking a hole into a wall two to three feet above the ground.

I suggest that Mr. Burn has a couple of hammers made which incorporate the above-mentioned modifications, and then asks a number of craftsmen to give them an unprejudiced trial for a couple of weeks or months. And I would, of course, be very much interested to hear of the results of such an experiment, should it take place.

Yours faithfully,
E. UCKO.

12 Ferndale Mansions,
Ferndale-avenue,
Durban,
South Africa.
October 9, 1957.

A.S.T.M. PUBLICATIONS

SIR, We were interested in your " On the Shelf " article (ENGINEERING, July 26, page 119) containing your reference to our list of our Special Technical Publications and your comment as to our inference that this list covers the years 1898 to 1956, but that you could not find anything listed for earlier than 1911.

There are two explanations. First of all, we have a *Fifty Year Index* in which all reports and technical papers published by the Society, from the year 1898 up to and including 1950, are listed and, secondly, we also have a *Five Year Index*, which supplements the above and completes the years 1951 to 1955. The pamphlet to which you refer indicates at the bottom of the first page that it is actually a reprint from the *Fifty Year Index* and the *Five Year Index*, supplemented and brought up to date to cover the year 1956; hence the date 1898 to 1956. This particular pamphlet covers only our Special Technical Publications, Supplementary Compilations of Standards, and Symposiums or Topical Discussions. There were no publications in the above categories printed up to 1911. Had we indicated that this list covered the years from 1911 to 1956, we would have been deluged for a similar list covering the years 1898 to 1910, and we would have had politely to reply that there were no publications in those years. I am sorry we took this defensive action of placing upon our little reprint the dates that caused some confusion. Technically, however, this list does cover all of the special publications issued by our Society from our beginning in the year 1898 up to the present time.

Very truly yours,
GEORGE A. WILSON,
Production Editor.

American Society for Testing Materials,
1916 Race-street,
Philadelphia 3,
Pa., U.S.A.
September 20, 1957.

Metals and Materials

MINING DEVELOPMENT IN IRELAND*

By M. A. Hogan, D.SC., M.I.C.E., M.I.MIN.E.

The past few years have seen a remarkable awakening of interest in mining development in Ireland, and in this paper I propose to review the causes of this activity and to discuss some topics of interest arising from it. In my opinion the most important factor has been the amount of attention devoted to this matter by the Government since 1940, both by way of legislation and by expenditure of public money. On the other hand, one cannot discount the effect of other factors such as world scarcity of certain materials, improved methods of ore treatment and new methods of prospecting.

The period since 1940 has been taken because the Minerals Development Act was passed in that year and also because my connection with Irish mining began then. At that time the only minerals being worked were coal and gypsum. These are still the most important mine products and the output has increased substantially, but we also have a useful production of lead and zinc ore, and of barytes. However, the projects for the large-scale mining of copper ore that have attracted the greatest amount of publicity are still in the development stage and have not produced any ore as yet.

LEGISLATION

Recent mining legislation has been aimed at making the development of our mineral resources more attractive to private enterprise. Although the State holds mining rights to much of the land of Ireland—because these rights have been retained for most of the land sold to the resident farmers since 1903—a good deal remains in private ownership. It is very difficult for a mining company to acquire the rights over a large area by private negotiation, and under modern conditions no one will spend money on prospecting except for a large area. One recalcitrant proprietor might hold up the whole scheme. Under the 1940 Act the Minister for Industry and Commerce can deal with this situation, either by acquiring the minerals compulsorily for the State and leasing them to a person with the skill and resources required to develop them or by the issue of an unworked minerals order, which has much the same effect. Apart from the right to work the minerals other rights may be involved such as the right to let down the surface, to use land, construct roads and watercourses and such like. These powers may be granted by way of a mineral facilities acquisition order. Of course, the exercise of compulsory powers gives rise to claims for compensation and to deal with these a Mining Board has been set up.

The first use made of the 1940 Act was the acquisition by the State of the Slievardagh Coalfield in County Tipperary; a statutory company was set up to develop the coalfield and a start was made in 1941 at Ballinunty. This site had been suggested by consulting mining engineers who had carried out, on behalf of the State, an investigation of the coalfield, including a certain amount of drilling in the years 1935-37. Their report was made available to interested parties and it was only when private enterprise was not forthcoming that the State took over the coalfield. From the report it seemed that a thickness of 18 in. of coal would be met, but in fact the thickness was less and the first colliery, which produced some 70,000 tons of coal in six years, did not make a profit. Nevertheless, the Government provided funds for a new start at Ballingarry where more detailed exploration was carried out and the coal was thicker. This colliery justified expectations and an output of 500 tons a week was reached by the end of 1952. Soon after, the mine was sold to a private company.

One important feature of Ballingarry Colliery is a modern coal-washing plant which enables it to supply high-grade fuel for thermal-storage cookers. The output has continued to increase and the new company have since opened another colliery on the main coal basin. These figures of thousands of tons a year may seem insignificant to visitors from a land where coal outputs are reckoned by thousands of tons each day, but it must be noted that the Ballingarry output at 500 tons a day was more than 10 per cent. of the Irish output. Now it is very much more. The question of size also arose in connection with the washery which we ordered for a throughput of 10 tons an hour. Only one manufacturer was willing to consider seriously an order for such a tiny plant.

A second State company—the Minerals Exploration and Development Company—was also established in 1941 to seek for and develop minerals other than coal. Whilst the Act authorised this company to cover a very wide field, in fact the growing problem of securing an adequate supply of superphosphate fertiliser directed attention to the two raw materials—iron pyrites and phosphate rock. The obvious source of pyrites was at Avoca, where the mining of pyrites had continued up to 1919. Phosphate rock was known to occur in Clare.

When the search for pyrites began at Avoca we had little knowledge of the difficulty of entering an area where mining had beeu practised for several hundred years and where the ground was honeycombed with old workings. The ores are complex mixtures of sulphides of copper, lead, zinc and iron, and, in the absence of modern flotation equipment, all that could be done was to pick the pyrites by hand from lump ore won from some remnants left behind by the earlier miners. At that time, most of the acid plants available required lump ore and could not have utilised flotation fines. Some 6,000 tons of lump pyrites were supplied for the manufacture of fertilisers.

In the summer of 1940 the late Judge Comyn started open-cast workings on phosphate rock at two sites in County Clare. At one of these, near Doolin, the bed of phosphate dipped under thick cover so that it could only be won by mining. The Minerals Company was entrusted with this task, and by the end of 1946 some 66,000 tons of phosphate rock had been produced.

A tax concession by way of a Mines Development Allowance was introduced in 1946. This permits the cost of development, plant, and machinery to be written off over the life of the deposit, or 20 years, whichever is the less. This concession did not prove attractive, and when it was desired to interest foreign capital in the development of Avoca, European and United States companies considered that the tax position would render such development unprofitable. Eventually, much more far-reaching concessions were approved which formed the basis for the lease of Avoca to a Canadian group. These provide that new mines working non-bedded deposits commencing business in the five years from April, 1956, will pay no tax on the first four years' operation, and half tax on the second four years. For mines working bedded deposits—e.g., coal—the concession is half tax for ten years. Existing mines are allowed half tax on the profits resulting from increased output.

MINERALS EXPLORATION

With the return of normal conditions it was decided to set the Minerals Company (then known as Mianrai Teoranta) to work on the exploration for minerals throughout the State and a seven-year plan was approved by the Dail in 1947. This plan envisaged the systematic examination of a number of known mineral areas. It was decided to begin with Avoca, the largest of the old mining districts and the one for which the most detailed information was available. In the event, owing to delays in starting the exploration and the fall in the value of money, it was found necessary to concentrate all the efforts at Avoca.

In the past, substantial quantities of iron ore, copper, and iron pyrites have been extracted at Avoca, the peak of activity being about 1850. A great deal of information was available with regard to the previous mining but the plans were by no means complete. The mineralisation occurs in large lens-shaped bodies up to 100 ft. thick and dipping at about 55 deg. These bodies showed local enrichment and the old miners limited their work to the rich veins within the lode. Thus, in many places examination of the old workings showed as many as five parallel stopes, each perhaps 3 ft. wide. What was left was not worth mining then or now.

It soon became clear that no useful result was to be obtained from an attempt to go over the ground already worked and that we should have to explore the virgin ground beneath the old workings. Under normal circumstances diamond drilling would have been employed, but at Avoca there was a history of failure of diamond drilling in the late 1920's. The Minister's other advisers considered that diamond drilling was unlikely to be successful in the somewhat broken ground that might be encountered and Mianrai Teoranta were not permitted to acquire diamond-drilling plant at the start of the exploration scheme. In these circumstances it was decided to carry out

* Abstract of paper read before Section G (Engineering), British Association meeting in Dublin on Thursday, September 5.

a deep-level exploration by deepening one of the existing shafts and driving a tunnel in the footwall parallel to one of the lodes (the South Lode). To explore the whole area of West Avoca and East Avoca would have required a tunnel 10,000 ft. long, but it was recognised that a much lesser distance might reveal sufficient ore to justify immediate development. This proved to be the case and in fact only about 2,800 ft. of tunnel was completed.

In deciding to drive a tunnel below the old workings the method of dealing with the water in these workings was a critical factor. At the outset the highly corrosive nature of the mine water was not realised, and, in fact, this proved to be a very critical factor. For example, in the early stages of our exploration when the water was discharged through an ordinary G.B. elbow at the top of the shaft, the elbow corroded through in a matter of 48 hours.

When a job of pumping out the old workings began in 1949 the supply of pumping machinery was still very difficult and makeshift appliances had to be used because the proper gear was not available. But it is also regrettable that many failures occurred due to carelessness in manufacture, e.g. the inclusion in a pump of parts of ordinary metal instead of a special alloy as supposed. These failures caused very serious delay to the scheme and much worry to the engineering staff.

From a consideration of the analysis of the water it was thought that even the normal stainless steels might be corroded and a high-chromium high-nickel alloy with molybdenum and copper but very little carbon (American Alloy F.A. 20) was selected. The pumps used at Avoca had two stages with a capacity of 330 g.p.m. at 500 ft. head. Trouble was experienced with the first of these pumps because the wearing rings were made of the same alloy as the impeller, but with the clearance normally used with bronze. The stainless alloy is particularly susceptible to scoring and one impeller was wrecked in the first few moments of the pump's life. A temporary repair was effected by replacing the wearing rings with bronze. Later the clearances were opened out from 0·008 in. to about 0·022 in. This caused a drop of about 2 per cent. in efficiency but enabled the pump to run for long hours without giving trouble. If these pumps were to be designed to-day, it might be worth while using a non-metallic material such as Teflon for the rings and shaft bushings.

Fresh water under the full shaft head was fed to the stuffing box glands on the pump shafts so as to eliminate wear or corrosion due to the use of the mine water. The ball bearings on these high-speed pumps were rather under-dimensioned and it was frequently necessary to direct a jet of fresh water to cool one or other of the bearings. Any error in alignment, or failure of the coupling between pump and motor quickly led to a broken shaft.

SAMPLING THE ORE

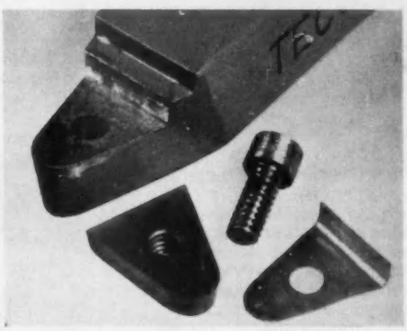
In dealing with such a low-grade ore as that at Avoca great care had to be taken to obtain a representative sample. With diamond drilling the greatest source of error was lost material. Some experiments were conducted in an endeavour to settle all mud coming from an underground drill hole in order to enable the analysis of the lost material to be determined. These experiments did not lead to conclusive results and it was decided to endeavour to make the coring as complete as possible and abide by the analysis of the cores as recovered. In the underground drilling about 80 per cent. of the core was recovered, and in the surface diamond drilling with thin-walled bits and double core tubes, 91 per cent. The normal practice was to split the core into two halves, use one for analysis and retain the other. Experiments showed that even this procedure caused some error in these rocks. The usual difference between check assays of the same pulp was sulphur, 0·15 per cent. and copper, 0·05 per cent.; but when the two halves of the same core were taken the differences were sulphur, 0·90 per cent. and copper 0·25 per cent. These values were established for cores with 5 to 10 per cent. sulphur and 0·5 to 3 per cent. copper.

The driving of cross-cuts through the ore body gave further opportunities for checking these drilling results. In this case some 400 to 500 tons of ore were obtained and from this it was possible, though with some difficulty, to obtain a representative sample. At this time an opportunity was taken to check the method of channel sampling that had been used in the earlier investigations at Avoca. The results showed that the sampler suffered from an unconscious bias in favour of the pieces of rock containing mineral and that the results of channel sampling tend to be misleading. The results of the West Avoca exploration were to show that at tunnel level the South Lode was 2,500 ft. long by 62 ft. wide with 1·13 per cent. copper and 5·6 per cent. sulphur, equivalent to 1·2 million tons per 100 ft. depth; the Pond Lode was 1,200 ft. long by 26 ft. wide with 1·31 per cent. copper and 8·1 per cent. sulphur, equivalent to 240,000 tons per 100 ft. depth. The vertical extension of the ore bodies as estimated from surface and underground drill holes, and from the old workings, gave estimated tonnages of 9 millions for the South Lode and 3 millions for the Pond Lode.

MINERAL COMPOSITION AND ORE DRESSING

The Pond Lode consists of chlorite schist with veins of quartz, quartz-carbonates, and ore minerals. The rock has been intensely pressed and the ore minerals are re-crystallised. The rock is rather soft due to the predominance of chlorite. The South Lode contains similar pressed chlorite schist but with more quartz. The ore minerals are similar in the two lodes. These are chalcopyrite, iron pyrite, and sphalerite which occur gathered in aggregates or in veins. The pyrite crystals vary considerably in size, and in some instances chalcopyrite occurs within the pyrite grains. In order to achieve liberation of the particles, grinding below 200 mesh sieve size is required. Flotation tests on these ores at the Royal Institute of Technology, Stockholm, showed that satisfactory chalcopyrite and iron pyrite concentrates could be made by two methods: (1) Selective flotation in which lince was added during grinding and a chalcopyrite concentrate floated off at a *p*H of 12. The *p*H was then reduced to 5·5 and a rough concentrate of iron pyrites floated off; (2) bulk flotation in which the total content of sulphides is first floated off to form a bulk concentrate which is reground with lime to produce a chalcopyrite concentrate as before, the iron pyrites being left as a residue. While the laboratory tests were not conclusive on this point, it appeared that only about two-thirds as much grinding was required for the bulk as for the selective flotation. Allowing for the saving in chemicals the difference in cost might be as much as 2*s*. on every ton.

TAPPING TUNGSTEN CARBIDE



Threading of brittle materials by an ultrasonic machining process has been achieved by Kerry's (Ultrasonics) Limited, Harold Hill, Romford, Essex. Threads can be tapped in very short machining times and on a commercial basis. Some of the uses visualised for tungsten carbide and other sintered materials prepared for use in this way are coal-cutting and boring machinery blades that can be detached without dismantling the machine, screwing dies for automatics, and turning tools with easily detachable tips. The illustration shows an example of the last application.

Detachable tools tip of tungsten carbide which was threaded by an ultrasonic process.

CENTENARY OF OPEN-HEARTH STEELMAKING

Last year the centenary of Sir Henry Bessemer's invention of the "pneumatic steelmaking process" was celebrated by the Iron and Steel Institute by the holding of an exhibition in London and the delivery of lectures on Bessemer and his work.

At the autumn general meeting of the Institute, held in London on September 24, the President, Mr. A. H. Ingen-Housz, made brief reference to the celebration during the forthcoming months of the centenary of another landmark in the history of modern steelmaking. This was the regenerative furnace for the melting of steel, invented by the Siemens brothers, Frederick and William, afterwards Sir William Siemens, F.R.S. The first patent was taken out in 1857 but much further work had to be carried out in subsequent years before the open-hearth furnace became an efficient production unit. At the Paris Exhibition of 1867 Siemens exhibited samples of his steel, and Dr. Pierre Martin, the French pioneer in the manufacture of steel by a regenerative process, did likewise, and these attracted a good deal of attention. Mr. Ingen-Housz stated that Siemens, who had been born in Hanover in 1823, became a naturalised British subject in 1859, was elected an F.R.S. in 1862 and President of the Iron and Steel Institute in 1877. He was awarded the Bessemer Medal in 1875, was knighted in 1883 and died in November of the same year.

Other announcements of interest made during the meeting were that Mr. C. R. Wheeler, C.B.E., a vice-president of the Institute and joint managing director of Guest Keen Iron and Steel Company, Limited, and a director of other companies, would take office as President at the annual general meeting in 1958, and that three vice-presidents of the Institute, namely, Mr. D. F. Campbell, Mr. I. F. L. Elliot, and Mr. G. H. Latham, had been made honorary vice-presidents.

HIGH-DUTY LUBRICANT

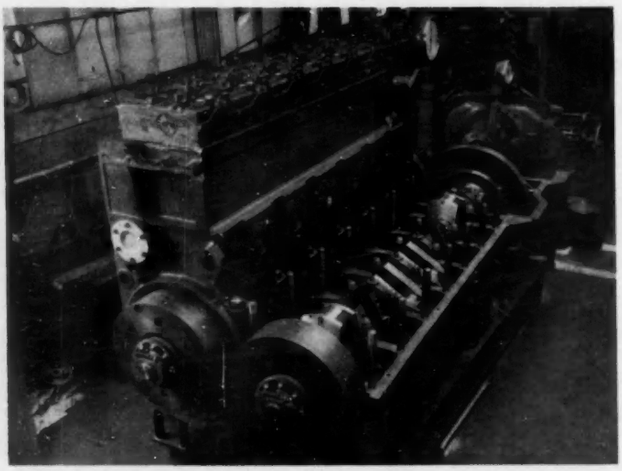
As loading increases between bearing surfaces, so the film of lubricant that exists between them becomes thinner until eventually it breaks down and metal to metal contact occurs. A lubricant for enclosed gears to handle very high loading has been developed by Revol Limited, Exchange Buildings, Quayside, Newcastle-upon-Tyne, 1. The "Reductol" scheme that they use involves two types of media for separating the gear teeth, made up as an unctuous solid in suspension in a viscous fluid. The solid is a superfine colloidal graphite marketed under the brand name of Voler Drylube A, and the liquid is Voler Reductol, a high-duty lubricating oil containing colloidal graphite in suspension and anti-corrosive E.P. additives, together with a silicone additive to reduce foaming. The scheme is to coat the teeth of the gears with the Drylube compound and then run them in the oil. It is claimed that scuffing is reduced very considerably; gains in lubricant film strength of up to 26 per cent. have been recorded.

DUAL-FUEL DIESELS

One of the advantages of operating a sewage works is that a supply of combustible gas is always available. This enables an integrated power system to be worked out. At Brancote, in Staffordshire, the sewage works have been equipped with three dual-fuel English Electric Diesel engines, of the 3 KD type. These are vertical naturally-aspirated engines of three cylinders each and 10 in. bore by 12 in. stroke; operating on the four-stroke cycle, they develop on the site 165 b.h.p. at 600 r.p.m. They are coupled direct to 110 kW alternators, also of English Electric manufacture. The methane gas generated during the digestive process is sufficient to drive one of the engines. Fuel oil is drawn from an underground storage tank and is used to drive the other engines in conjunction with the gas. Power generated by the plant is used in the works for pumping and cleaning. As far as possible operation is completely automatic, the pumps handling the effluent starting up in sequence according to the flow that occurs.

Plant and Equipment

TWIN-BANK DIESEL



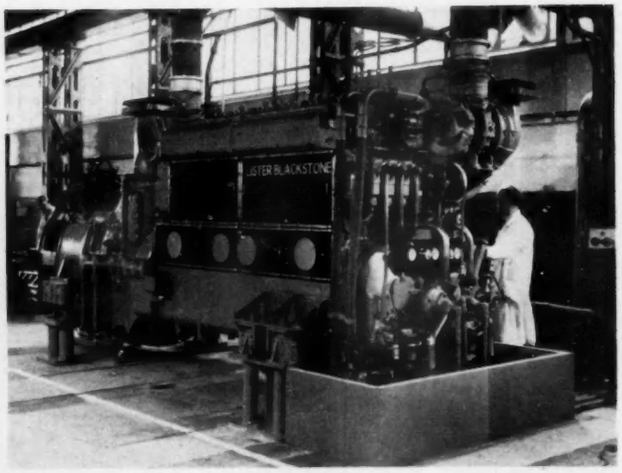


Fig. 1 (above) The twin-bank arrangement with separate crankshafts offers less complications than a V formation, while yet effecting a considerable saving in weight. Either bank can be run alone.

Fig. 2 (above) Parts have been standardised as far as possible with the in-line engines already in production. Torsional dampers are fitted to both crankshafts.

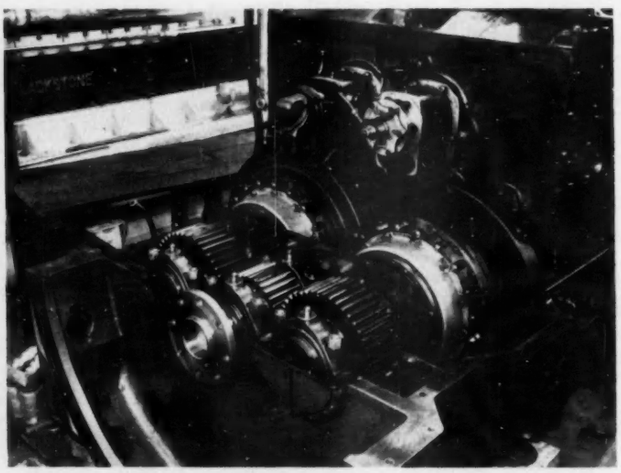


Fig. 3 (right) The crankshafts drive a common output shaft through gear wheels and pinions which can be interchanged to vary the ratio.

TWIN-BANK Diesel engines of 12 and 16 cylinders with outputs per cylinder ranging from 45 b.h.p. to 82·5 b.h.p., have now been introduced by Blackstone and Company, Limited, Stamford, Lincolnshire. The engines have been developed from the EV and ER series of in-line engines, which give a maximum output of 660 b.h.p. at 750 r.p.m. from the largest (8-cylinder) unit. The new models can be either normally-aspirated or turbo-charged. There are also two standard speeds of 600 and 750 r.p.m., the former being designated EV12 and EV16 and the latter ER12 and ER16. A common base carries the two vertical banks of cylinders which are bolted back to back, each bank driving a single crankshaft. Each bank may, in fact, be considered to be a separate engine, as it is complete with its own governor, running gear and oil and water pumps. The common output drive is taken through a gearbox built-in to the flywheel end of the engine.

Each crankshaft is fitted with an hydraulic damper at the forward (free) end, and a flywheel of the largest practicable proportions at the drive end. The flywheels are actually offset so that they overlap, and their chamber is open to atmosphere. An essential feature of the twin bank drive is that between each flywheel and input gear to the gearbox is interposed a Blackstone nodal damper coupling of patent construction, which provides both great flexibility and also a high degree of viscous damping. The flexibility (5 deg. twist on full load across rubber in shear) produces a smooth driving torque protecting the gear teeth from shock loading and preventing gear hammer, while the viscous damping, in conjunction with the hydraulic dampers fitted to the crankshafts, eliminates harmful torsional vibrations within the working speed range of the engine, irrespective of the driven unit.

The gearbox built-in to the flywheel end of the engine is a completely self-contained unit transmitting power through straight spur gearing from the two individual banks to a common output shaft. The lower half of the box is formed in the engine base and the upper half is enclosed by separate removable covers.

Both gearwheels and pinions are heat treated and ground, being of steel to B.S. En9 and En33 respectively. The gearwheel and pinion shafts are carried in large diameter forced-lubricated bearings in close proximity to the gears, the bearing shells being identical to those used for the crankshaft journal bearings. The gears are housed in a casing entirely separate from the main engine crankcase and are lubricated from an independent supply to enable the most suitable gear oil to be used irrespective of engine requirements.

A feature of the gearbox is that pinions and gearwheels have been designed to be interchangeable so that both speed increase and reduction ratios may be obtained using standard gears at a fixed centre distance. With a ratio range of 1 : 1·57 to 1 : 0·71, this means that for industrial applications the output shaft speed can be tailored to suit the customer's requirements for all speeds between 1,200 r.p.m. and 425 r.p.m. For main propulsion duties reduction ratios up to 3 : 1 are available.

Twin-bank engines are normally cooled using fresh and raw water systems with one heat exchanger and oil cooler per bank, and a further oil cooler for the gearbox lubricant. Radiator cooling is available as an alternative, with the fan either motor driven or powered from a forward extension shaft in one of the engine crankshafts.

Starting is by means of compressed air to all cylinders or, especially for traction duties, series windings may be included in the generator to enable electric starting to be employed.

The arrangement of base and cylinder housings gives a construction of great rigidity and avoids the use of a complicated big-end bearing design as is necessary in a V-type engine. Ease of accessibility is maintained by the provision of large side, end and top covers which may be readily removed to expose all working parts for servicing.

The side-by-side arrangement of the engine banks not only results in smaller foundations being necessary with reduced overall length and height compared with an equivalent power output from conventional engines, but also allows for lighter handling equipment for maintenance and smaller and more manageable spares—points of especial importance for marine and rail traction applications.

As for the corresponding in-line EV and ER series, the individual cylinder heads may be removed for servicing without having to displace the water, air or exhaust manifolds, and the piston and connecting rod assemblies may be extracted either vertically through the bore of the liner or, where overhead space is limited, through the side of the cylinder housings.

Another advantage is that the twin-bank development is based almost entirely on the use of standard EV and ER components; thus a range of engines is available from 90 to 1,500 b.h.p. all of the same cylinder dimensions, employing standard crankshafts, liners, pistons, connecting rods, big-end and main bearings, cylinder heads, tappet blocks, camshafts, valve gear, governors, and water and oil pumps. This duplication of components greatly simplifies the question of spare parts and allows considerable economies to be made both during manufacture and with regard to the stock of spares which must be held by the engine users and distributors.

SINGLE-BANK RUNNING

If an engine is required to operate for extended periods on low load, the duplication of working

systems permits more economical running to be obtained by closing one bank down completely as a temporary measure. This can be carried out by disconnecting the drive of the bank to be isolated at its input coupling to the gearbox. This, incidentally, also enables half power to be developed in an emergency should a fault develop in one bank.

Since for main propulsion duties it is often impracticable to have the main engine inoperative while such a conversion is being carried out, an additional clutching arrangement is available which will enable either bank to be isolated.

Twin-bank engines designed for single-bank operation are fitted with a duplex governor system so that each bank is under the control of its own governor. Balanced governor response and equal sharing of load between banks is ensured by the hydraulic feed to both governors being controlled by a single pilot valve: also, both governor outputs contribute movement to a common floating linkage, the mean deflection of which is used to control the fuel pump racks of both banks of cylinders.

For use in rail traction, a fabricated steel-construction is available for the engine base and cylinder housings, instead of the standard castings. For traction duties, the maximum crankshaft speed is 800 r.p.m., giving a rating for the largest unit of 1,540 b.h.p. For turbo-charging, two Napier chargers are used, one for each bank, mounted at opposite ends of the engine. An improvement in the life of the needle seats of the C.A.V. injectors has been obtained by turning-down the main spindle, leaving a guide section at mid-length.

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SILICON SEMI-CONDUCTORS

A new source of supply of silicon transistors and rectifiers has recently become available in the United Kingdom with the opening of the Dallas Road, Bedford, factory of Texas Instruments Limited—the first British subsidiary of the American electronics and geophysics firm, Texas Instruments Incorporated. The parent company claim to be the largest commercial manufacturers of germanium and silicon transistors in the world. The British firm is to concentrate on silicon semi-conductor products.

The main advantage of silicon for rectifiers, it is claimed, is the high efficiency achieved which, in turn, enables the unit to be made very small in size and very light in weight compared with other devices of similar ratings. This is particularly important where space is restricted such as in guided weapons and aircraft or where large numbers are involved, as in digital computers and telephone systems. Silicon rectifiers can operate at sustained high temperatures, up to 150 deg. C. Texas are currently producing silicon rectifiers having current ratings of 400 milliamps and 750 milliamps with peak inverse voltages ranging from 200 volts to 600 volts. In the very near future rectifiers with current ratings up to 5 amps. with similar peak inverse voltages will be introduced. Development work is also well advanced on units with really high current ratings which will widen considerably the application of these devices on the power side to generation schemes, traction and welding.

The particular characteristic which distinguishes the Texas range of transistors from those previously manufactured, the producers claim, is their ability to operate with stability at the high temperatures which are inevitable for equipment used in aircraft and guided weapons. The comprehensive range from this company makes possible the introduction of transistors into a far wider field of application than previously possible. For instance, the currently available high-frequency tetrode enables amplifiers to be designed to operate up to 30 megacycles. A recent addition to the range on the power side is a unit which has a dissipation of 37·5 watts at 25 deg. C. and 15 watts at 100 deg. C. which, it is believed, will have a significant impact on the design of servo amplifiers.

Light weight and safety in operation are features of the " Hicycle " impact wrench. It is designed for bolt sizes from ⅜ in. to ⅝ in.

ELECTRIC IMPACT WRENCH

A new impact wrench has been introduced by the Consolidated Pneumatic Tool Company, Limited, 232 Dawes-road, London, S.W.6. It is designed for use on bolt sizes from ⅜ in. to ⅝ in., and is powered by the " 157 Hicycle " electric motor used in other models in the manufacturers' range of drills, screwdrivers and nut runners. The overall length of the wrench is 12½ in., and the net weight, without the detachable angle head which is available as an extra fitting, is approximately 8 lb.

An adjustable deflector for directing cooling air away from the operator is incorporated. Accidental reversing while the wrench is running is prevented by a safety reversing switch, reversing being under the control of one finger. Among the available extra equipment, in addition to the angle head already mentioned, is a universal joint for ½ in. drive at either end.

MAGNETIC TAPE CONTROLS MACHINE TOOLS

Spar and skin milling machines controlled by magnetic tape are now in use in United States aircraft and missile plants. In the method applied to the machines of Giddings and Lewis Machine Tool Company, Fond du Lac, Wisconsin, a " split " system is used. This entails the use of an interpolator that translates information of a discontinuous nature—such as that supplied by punched cards—into information of a continuous nature suitable for machine control.

The first step in numerical control systems is to take key co-ordinates from the blueprints and code them on punched cards or tape. A rough outline of the curve to be machined is given by these co-ordinates. The punched material is then fed into an electronic computer that calculates all the intermediate co-ordinates and codes them on further punched material. It is this material that is fed to the interpolator.

The interpolator records its continuous output on magnetic tape. Machine tools may be controlled for periods of 1½ hours by a reel of tape 1 in. wide and 14 in. in diameter. The Giddings and Lewis control system employs tape manufactured and supplied by Minnesota Mining and Manufacturing Company, Limited, St. Paul, Minnesota.

Systems that do not use magnetic tape require the interpolator to be located at the machine. However, with the split system the interpolator can be located in an office atmosphere and the tape can be played through a relatively simple unit on the machine tool. Also, it is possible to take advantage of the interpolator's high speed, since tapes can be prepared many times faster than they can be played back with the machine tool in operation. A single interpolator can be used to produce tape for many machine tools.

BRITISH STANDARD OIL FUELS

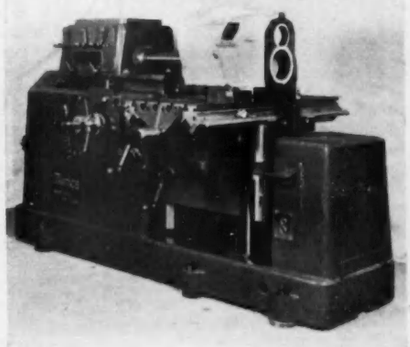
In view of the increasing use of burner fuels in oil engines it has been considered that the perpetuation of the two existing British Standards, namely, B.S.209, dealing with " Fuels for Oil Engines," and B.S.742, covering " Fuel Oil for Burners," is unnecessary. B.S.209 was first published in October, 1924, and B.S.742 in July, 1937; both were last revised in October, 1947.

One Standard, under a new number—B.S.2869:1957, has now been issued, thus collecting all the oil-fuel grades and test methods conveniently together under one cover.

The Standard specifies requirements for three categories of fuels, namely, (i) engine fuels, (ii) domestic fuels, and (iii) industrial and marine fuels. There are two classes of engine fuels, one class of domestic fuel, and four classes of industrial and marine fuels. For each class of fuel there is a table specifying properties and the limits for the various impurities. Methods of test are specified for each property and impurity.

The committee responsible for the Standard recognise that there are some specialised applications for which it may be necessary, for technical and other reasons, to require limits other than those stipulated in the Standard, but it has been deemed undesirable to attempt to cater for these diverse applications.

Copies of the new Standard may be obtained from the British Standards Institution, 2 Park-street, London, W.1, price 7*s.* 6*d.*, post free.



This Milnes heavy-duty fine boring machine has a traversing head which feeds in while the work remains stationary. The powered boring head is mounted on V-slides.

HEAVY-DUTY FINE BORING MACHINE

Made by Henry Milnes Limited, Bradford, and marketed by the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, the boring machine illustrated herewith has a powered boring head mounted on V-slides, and a traversing work table 48 in. by 19½ in. During boring the work remains stationary and the boring head moves in to give the required feed. The work can be moved vertically 15 in. by power and 30 in. horizontally by hand; the table is equipped with steel scales and verniers, as well as length-measuring rod equipment. Precision scales with optical verniers made by Hilger and Watts Limited can be supplied as an extra.

The boring head is arranged for power and hand feed over its maximum travel of 19½ in., and has, in addition, rapid traverse for both forward and reverse movements. There are twelve spindle speeds, from 40 to 750 r.p.m., with four power feeds, 0·0025, 0·005, 0·010 and 0·020 in. per revolution of the spindle.

Management

Weekly Survey

The Battle of the Desk

In many sales organisations insufficient attention is paid to the importance of the sales office as opposed to that of the sales representative. This may be particularly true where the sales manager, as is so often the case, has himself been promoted from a sales representative or area manager and feels that he ought to spend a great deal of his time outside the office engaged in active selling instead of "wasting his time behind a desk." Yet the best sales representatives may achieve only indifferent results unless they are adequately supported from headquarters.

A paper entitled "The Battle of the Desk: One of the Fundamentals of Sales Management," which was read last week to the Incorporated Sales Managers' Association by the sales manager of Smith's Delivery Vehicles Limited, may well therefore be of considerable interest. The company have offered to make available a copy of the paper to any company executive who cares to write to them. While it does not set out to plan the office organisation in detail, the paper sets out some of the criteria of efficient correspondence and suggests a number of methods by which these can be achieved. For example, the criterion of efficiency suggested for the filing system is that a stranger who has never been in the office before should be able to find any particular letter without undue difficulty. This may seem very difficult to achieve, yet otherwise, it becomes virtually impossible to attain another important objective—that every communication reaching the office during the day should have been dealt with before anyone goes home at night.

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Export and Overseas Sales Promotion

The increasing attention which is being given by individual United Kingdom manufacturers to the probable advent of the European Free Trade Area was one of the underlying reasons for the two-day conference on exports and overseas sales promotion sponsored by the Federation of British Industries' Scottish Council and held at Gleneagles on last May 31 and June 1. The report of the conference was published last week and is now available from the F.B.I., 21 Tothill-street, London, S.W.1, price 1*s.* 6*d.* Another report concerning industry's part in the Free Trade Area, available from the F.B.I., was discussed in Weekly Survey last week.

The conference covered a range of subjects including entry into new export markets; the appointment of agents overseas and the relation which should be maintained with such agents; and advertising and public relations in overseas countries with particular emphasis on policy for overseas exhibitions and trade fairs.

With regard to entry into new markets, one of the conclusions reached was that a company should have a firmly established home market for its products before entering the export trade and should then carefully select foreign markets suitable for penetration. In this connection the point was made that American manufacturers tend to spend more time than British on market research. There was a tendency to challenge this on the grounds that United Kingdom exporters usually carry out a good deal of initial survey work without, in fact, referring to this as a market survey.

In fact it would appear that many companies rely on published trade statistics and on information available through the Board of Trade from H. M. Commercial Officers and Consuls abroad. The general opinion expressed was that this information, with certain exceptions, was unsatisfactory. Nevertheless inadequate use appears to be made of independent market research organisations.

In one group at the Conference the point was made that a visit should be paid to a potential market by a senior executive, but before this was done a thorough investigation should be made from this country. The overall impression obtained on this subject is that there is undoubtedly scope for a great deal more market research than is, in fact, carried out, and this need is likely to increase when concrete plans are being made for participation in the Free Trade Area.

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Publicising Careers

An opportunity for industry to "sell" careers to school children, their parents and their teachers, will be offered by the National Education and Careers Exhibition. Sponsored by the National Union of Teachers, the exhibition will be the first organised on a national scale that is devoted exclusively to what the country gets for the £700 million it is now spending annually on education. All Olympia will be taken and half the exhibition will be set aside for authorities and firms—the latter working either individually or through their trade associations—to show off the work they do and to present the career opportunities they have to offer.

Among the industrial organisations who have agreed to help are the Federation of British Industries, the British Employers' Confederation and the Trades Union Congress. Local authorities have also promised to allow hundreds of teachers and youngsters to take part in live demonstrations and for thousands more to visit Olympia in organised parties. The sponsors hope that all aspects of public education to-day will be represented on the stands: teachers and children will show parents and industry what goes on in the schools, and industry and commerce will be able to show the schools what they have to offer both in terms of equipment and jobs for the future. The scope will be as wide as is modern education, including the universities and technical colleges.

The dates of the exhibition are from May 25 to June 4, 1959; the exhibition director to whom enquiries should be addressed, is Mr. F. Jarvis, and his address is at the offices of the N.U.T., Hamilton House, Mabledon-place, W.C.1.

★ ★ ★

Opening the Throttle

British Railways are taking very seriously the freedom they won under the Transport Act, 1953, to behave "like any other commercial undertaking." Progress is being made under their plan for modernisation and the main lines of development are becoming clear. A detailed and most stimulating account of what is being done and how it fits into the full context of their plans and intentions were given in a paper given to the National Conference of the Purchasing Officers' Association at Folkestone by Mr. J. R. Pike. Mr. Pike is chief commercial officer, Railways Division, British Transport Commission, and his paper was entitled "Selling Railways Service." It was, in fact, a clear statement of the Commission's practical intentions and how they are to be achieved. As such its value as a sales document is high, and the Commission could do worse than to use it in putting their case to users and employees alike.

Mr. Pike makes the point strongly that more is needed to make the railways a live and efficient organisation than the injection of new equipment. "Modernisation," he said, "is a means, not an end. It is no use replacing the hardware unless there is to be at the same time a rejuvenation over the whole field of business and human relationships." It is this new outlook that he conveys so clearly. He states the "practical intentions" of the Commission as follows: to encourage traffic consigned in large quantities and full wagon loads; to develop regular traffics for which economical services can be arranged; to attract good loading traffic, much of which now passes by road, for long and medium distances; and to avoid losses on some short distance traffic. The 1957 edition of the Commission's booklet, *Facts and Figures about British Railways*, illustrates what these intentions will mean, in terms of present performance.

There is space only to mention some of the steps that are being taken to increase efficiency. Decentralisation and closer links with regional industry will be achieved by the creation, within each region, of "relatively small areas," each with a traffic manager who will be "approachable by industry and by railway staff alike and will be able to settle many questions on the spot, partly because he will be in charge of commercial, operating and motive power work, and partly because authority will be delegated to him on most matters except those affecting Regional policy." Considerable efforts are being made to encourage staff to become interested in productivity and work study. Much of what Mr. Pike says about re-equipment is well known, though some of the facts, for example that trunk haulage occupies a relatively small proportion of the time to convey a wagon from start to finish of its journey, may not be widely appreciated. Details are given of the extensive re-grouping and reorganisation of terminals and marshalling yards to reduce costs which arise in connection with terminal services, including haulage, shunting and marshalling (over 40 per cent. of the total). Many other improvements are mentioned, including better communications to provide prompt "business-like" service.

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Industrial Opportunities in Durham

In these days of full employment much less is heard of the need for industrial development of particular areas of the country than was the case before the war. Nevertheless, although young people for whom no suitable employment exists in the district in which they live, may have no great difficulty in finding a job elsewhere, it is unfortunate that they should be compelled to emigrate to already congested industrial areas if there is any prospect of providing economic employment for them at home. In publishing early this month a booklet called "Industrial Opportunities in Durham," the Durham County Council therefore made a useful contribution not only to the future development of Durham but also to that of the country as a whole.

The booklet points out that between 1951 and 1955 some 22,000 people, mostly young, left Durham. In spite of this the total working population of the county, which stands at 587,000, is growing; there is a surplus of labour in the area and a large untapped source of female labour. An interesting point brought out in the booklet is the low incidence of industrial disputes in the area. Over all industries the number of working days lost due to disputes per 1,000 population was only 57 in the Northern Region (of which Durham provides almost half of the insured population) against 112 for the United Kingdom as a whole. Other sections of the booklet deal with communications, markets, services, education and amenities.

The booklet contains a list of industrial sites and of the principal companies operating in the county. Of the latter, representatives of three companies which have established themselves in the area since the war, Bakelite Limited, Ransome and Marles Bearing Company, Limited, and Thorn Electrical Industries Limited, spoke at the Press conference which launched the booklet. The wide range of activities covered by these three companies alone suggests that there must be others which could with advantage consider the establishment of factories in Durham where labour wastage might prove much less serious than it is in many other parts of the country.

Engineering at Home

VOICE OF THE USER

Technology flourishes in fields more extensive than those of laboratory and production plant. Its insistent entry into people's lives is not to be checked. In the home, goods and materials appear as the products of modern engineering techniques. A situation has arisen in which consumer goods often cannot be assessed by the layman, but require instead the yardsticks of technology.

In such circumstances it is understandable that consumer goods should be receiving greater attention from the British Standards Institution. The need for information to the consumer, as a prerequisite to wise buying and informed use of standards, has recently been much emphasised. The precedent set six years ago by the glossary of terms for describing wool fabrics (B.S.2020) has lead to further exploration of the possibility of standard terminology for textile goods generally. Standards have also been drawn up for such things as electric cookers and cleaners, asbestos cement cisterns, and coke-burning open fires; and the list is increasing. To further the work in this field, the Government grant to the B.S.I. this year includes an appropriation of £10,000 specifically for work on behalf of consumers.

As all British Standards are drawn up by producers and users working together, the B.S.I. has set up the Consumer Council to advise it. The council consists of 25 people with specialist knowledge of the shopper's needs. It meets once a quarter and between meetings the council's recommendations are worked out in detail by technical committees of manufacturers, distributors and technologists, who do the main work.

To provide a link between the council and the public, a scheme for associate membership (10*s.* a year) has been started. An associate member receives a periodical, *Shopper's Guide*, that gives advice on choosing goods. In addition, an important part of the scheme is the collection of information from the shoppers about what they want—to pass back to the industry and the retail trade. Information in the guide is based on the tests and reports of independent research organisations and similar bodies, and the articles appear to be chiefly directed at the housewife.

While the complexity of domestic goods has increased, so also has the following of the do-it-yourself movement. This latter is by no means a return to the primitive. New ranges of power tools are available to the amateur craftsman: furniture kits can be had for tables, bookcases, sideboards, etc.; high-fidelity sound equipment is available in kit or unit form; the chemical structures of paints have been developed so that they are easier to apply. In fact, the amateur craftsman deals with materials that are far from simple. He no longer starts his furniture building by choosing a suitable wood, but chooses instead a suitable laminated plywood veneer. In such circumstances the B.S.I. can be of great value in setting up standards. In doing so they give valuable guidance to the non-specialist.

However, a distinction is to be made between the equipment that is just good enough to reach the standard and that which is very good indeed. Miss Marghanita Laski, in an article in *Design*, raises this point and suggests that informative labelling is needed to give a means for making qualitative judgments at the point-of-sale. It is worth noting that although a piece of equipment may have reached a certain standard, it does not mean to say that the claims made in the manufacturer's leaflets are borne out. The vast majority of gas cookers conform to British Standard 1250 but the manufacturers do not require official approval for their leaflets, which sometimes contain claims for high speed, low gas consumption, and other virtues which are not substantiated under test.

A comprehensive system of standards and labelling will not be brought about without a great deal of effort. But the effort will be worthwhile: the consumer has a right to be protected against shoddy goods when specialised knowledge is needed before their failings become apparent. In addition, such a system could lead to a great deal of time saving. It would make accurate cataloguing of goods possible and so make ordering easier.

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SMALL-BORE HEATING

How an oil-fired boiler can provide fully automatic central heating and hot water for the average-sized home is being shown by a working exhibit on the stand of Shell-Mex and B.P. Limited, Strand, London, W.C.2, at the Building Exhibition opening at Olympia on November 13. The heating system depends on the forced circulation of hot water through small-bore copper pipes by an electric pump. As the pipes are less than $\frac{3}{4}$ in. outside diameter they can be fitted neatly along skirtings, over door frames, etc., so that the system is suitable for existing houses as well as new ones.

Heat is provided by an oil-fired boiler suitable for houses up to 1,800 sq. ft. A room thermostat, which normally would be fitted in the hall or living room, controls the temperature of the radiators. An independent boiler thermostat controls the temperature of the hot water from the taps.

HOT AIR FOR HOUSES

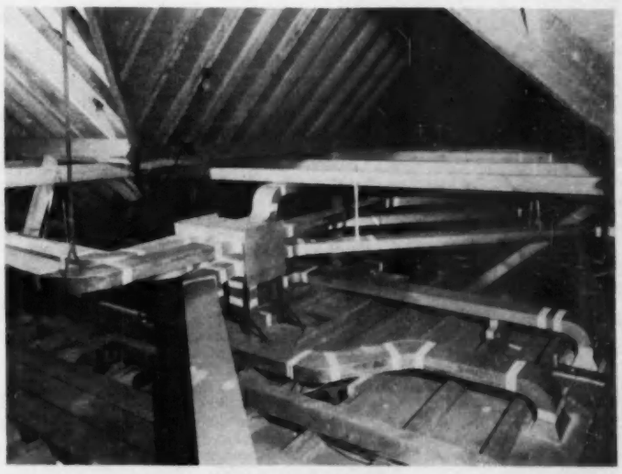
High in the list of home necessities stands the need for warmth. Of the three basic modes of heat transfer that can be employed, conduction and radiation are the least satisfactory. Both produce localised heating. And although radiation plays an important part with heating sources like the open fire, most systems rely on air convection to distribute heat evenly. Heat exchangers of various efficiency stand in every home.

In their system, the Package Heater Company, 268 High-road, Harrow Weald, Middlesex, take the foregoing argument to its conclusion. They design the heat exchanger as such, and make it a self-contained unit. The hot air from it is ducted about the house to diffusers in each room. Such a form of heating brings incidental advantages. The air within the house is slightly pressurised and so reduces the ingress of dust and draughts. Also the circulating air can be continuously filtered. If need be, it can be taken through a steriliser.

Air circulating through the heat exchanger enters at 55 deg. F. and leaves at 120 deg. F. Within the unit a heater battery is situated that must be supplied with hot water from a suitable capacity boiler. The water enters at 170 deg. F. and leaves at 150 deg. F. In the unit an integrally mounted pump aids water flow. A single-phase electric motor drives a centrifugal fan which circulates the air.

Used air returns to the "Pak-a-way" unit—as the heat exchanger is called—through a central opening at a high level on the upper floor. Fresh air is added before reheating. To show typical temperatures existing in a system, the makers give the following table:—

Air temperature rise through unit	55-120 deg. F.
Room air inlet temperature (allowing 10 deg. F. drop in distribution system)	110 deg. F.
Living and dining rooms	65 deg. F.
Hallways, corridors and landings	60 deg. F.
Bedrooms	50 deg. F.
External temperature	32 deg. F.
Temperature drop through ceiling to unheated bedroom	25 deg. F.
Fresh air (20 per cent.) temperature at main return opening	32 deg. F.
Return air (80 per cent.) temperature at main return air opening	60 deg. F.



Rectangular ducts carry the hot air to various rooms. In the illustration the Pak-a-way unit can be seen behind the main distributor.

The heat exchanger produces a static external pressure of 0·33 in. water gauge. Under its influence the air is carried about the house by rectangular ducts measuring 3 in. by 7 in. Each duct allows a flow of 100 cub. ft. per min. at an air speed of 750 ft. per min. At the ends of the ducts are diffusers, of which there are two types. Each type has a free area of $\frac{1}{2}$ sq. ft. The warm air enters the room at between 300 and 350 ft. per min. At this speed no draught is produced.

If the diffuser is near the floor, the air leaves the room through a grille above the door. Alternatively, when the diffuser is high up, a clearance of $\frac{1}{2}$ in. at the bottom of the door provides sufficient exit. The total capacity required of the heat exchanger in a given house is estimated by dividing the sum of the volumes of the living room, drawing room, hallway, and upper-floor landing by twelve. Pak-a-way units vary between 300 and 800 cub. ft. per min. in capacity. One such unit can be seen in the illustration, which shows an installation in a loft. But the unit can be fitted anywhere in the house. Also in the illustration the standardised galvanised iron ducts can be seen leaving the plenum distributor fitted to the unit.

Research and Development

ADVANCES IN AERONAUTICS*

By W. H. Stephens, M.SC., F.R.AE.S.†

Concluded from page 468, October 11

Having described some of the more interesting problems which face the aeronautical research world to-day, let me turn now to a glimpse of the likely fruits of such research. They can be summed up in three words: higher, faster, further.

Vertical lift may well be the answer to the problem of operating conventional land aircraft from comparatively confined areas; the problem is to achieve it economically. In general, engine power always contributes something towards vertical lift, if only because of the inclination of the thrust line to the horizontal. This component, plus the effect of increased velocity in the slipstream over the wing, did produce quite significant increases in lift on some of the high-powered piston-engined fighters of the second World War, particularly while landing.

Development has recently been along two main avenues. In the first, the aim is to increase the lift so as to allow the use of slower take-off or landing speeds, although the aircraft is otherwise operated conventionally, with no change in cruise or top speed performance. In the second case, true vertical take-off and landing is the target, without the disadvantage of the low top speed of the helicopter.

LIFT AUGMENTATION

It was the advent of the jet engine, offering a source of compressed air, which made the application of boundary-layer control for high lift into a practical proposition. The best-known scheme taps a proportion of the engine mass flow from the compressor, and ejects it at supersonic speed from a spanwise slit ahead of the wing flaps, Fig. 10. The airflow is thus constrained to remain attached to the flaps, which consequently produce a much larger lift increase than otherwise. Careful adjustment of slit position, plus precautions to ensure attached flow ahead of the flaps, can produce a 25 to 30 per cent. reduction, for example, in landing speed. The usefulness of this "blown flap" system may be limited by large changes in longitudinal trim, or by any inability to use, while landing, a large enough throttle opening to produce the air needed to get the best out of the system.

In what appears, at first sight, to be only a logical extension of this scheme, the whole of the exhaust efflux of the jet engine is ejected from a spanwise slit. In fact, the flap acts only as a turning device and the jet sheet itself acts as the flap—this is the jet flap system, Fig. 11. This scheme entails a much closer integration of engine and wing structure, if long, wasteful ducting is to be avoided, but tests show that lift increases of the order of 10 times those of the simple flap-blowing scheme are possible. This offers the attractive possibility of reducing landing speeds to one-half or even one-third of current values, provided that stability and control problems can be overcome. On the cruise, of course, the jet sheet is undeflected, and it is claimed that speed and range need not be adversely affected, if appropriate engines are used.

In the third main group of lift augmentation devices, the thrust line of the main engines is deflected to produce a vertical component, which, in effect, is equivalent to a reduction in the weight of the aircraft. The deflection angle that can be used depends on the thrust/weight ratios, since a certain minimum horizontal component should be maintained. The thrust line must, at all times, pass through or near the centre of gravity of the aircraft, in order to eliminate trim changes.

V.T.O.L.

In the wide field of vertical take-off and landing systems—in which for a long time the helicopter was the only contender—there are now two main groups of possible solutions: (*a*) those in which the lift-producing mechanism is separate from the normal propulsion system, and (*b*) those with a single power system for producing lift and propulsion. In the first category there are two main methods of producing lift for vertical take-off and landing—by turbojet or by ducted fan.

In the turbojet method, the aircraft is supported, in the normal flight attitude, by the thrust from a number of vertically-mounted jet engines. Obviously, engines with very high thrust per lb. of installed weight are required, and this seems to lead to a large number of small engines, rather than to a few very large engines. The trend towards small, short engines eases the installation problem, and also the problem of control following engine failure. For adequate vertical control, the small engine would give a better thrust response than the larger type. A thrust of 1·15 to 1·2 times the aircraft weight seems to be required.

The external noise level associated with direct jet lift will be very high indeed, and a specially prepared base will also be required for its operation, to eliminate erosion and to reduce ground-interference effects.

Fuel consumption while hovering is very high, and hovering time must be kept to the minimum. The lifting engines may be capable of being tilted fore and aft to assist in accelerating the aircraft to normal flight speed, but on the cruise, except in certain circumstances, they may be so much dead-weight. This system is therefore only economical if the added lift-engine weight is less than the saving in structure weight that can result from an aerodynamic layout (e.g., a narrow delta) designed to meet the high-speed case only. This, according to Griffiths, is the case if the cruising speed is Mach 2·5 or higher.

In the ducted-fan layout, vertical lift is provided by one or more fans embedded in the wings or fuselage driven by the diverted exhaust gases of the main engines through a turbine which may be either a separate unit, or may be built round the periphery of the lifting fans. Power transmission by shafting from a central turbine is probably the more economical.

It is claimed that these fans can increase the vertical lift by a factor of 2 or 3, thus reducing the number of jet engines that are needed. This gain must, of course, be balanced against the weight of the fans themselves plus the structural penalty of the large cut-outs in the wings.

The essence of single power systems is that the main power plant should be capable of producing a vertical static thrust greater than the weight of the aircraft and of producing thrust economically for cruising. The helicopter achieves this result, for example, by tilting the main rotor, and most of the layouts in this category work on this same principle of changing the direction of the thrust line, either by a system of deflectors to change the jet or slipstream direction, or by a rotation of the whole aircraft as in the case of the tail-sitting aircraft. The choice of system depends on top speed and length of hovering time required.

Fig. 12 illustrates the Short S.C.1 experimental V.T.O.L. aircraft. Earlier experiments on hovering flight have been made by a combined team of Rolls-Royce and Royal Aircraft Establishment scientists, using the contraption popularly known as the "Flying Bedstead."

The application of similar principles to man-carrying machines for Army use has been developed in America (Fig. 13). The day when one will need a garage with both movable doors and roof may not be so far ahead as we think! In the meantime, the practical application of vertical lift in the helicopter has developed rapidly during the last five years. From sea or mountain rescue to antarctic exploration, anti-submarine detection and the towing of stranded bulldozers, the helicopter continues to prove its versatility as a working lift horse of moderate power. Nevertheless, its effectiveness is still limited by its poor flying characteristics. In particular, it is a very unstable machine. For example, if the control stick is held fixed, a divergent oscillation in pitch results which may more than double its amplitude each half cycle and which has a periodic time of, say, 10 to 15 seconds. In roll the result is similar but the period is shorter. As a result of this, a high level of pilot concentration is required and this results in early fatigue in tasks requiring precision flying, e.g., hovering over a point for a rescue. Instrument flying is virtually ruled out except for limited periods over a small speed range in forward flight. Thus the helicopter cannot easily be used, for example, for rescue at night or in bad weather.

The range of an aircraft with given payload, however, is determined by three important parameters, the lift/drag ratio, L/D, the engine thrust horse-power per unit of fuel consumed per hour, and the ratio of total weight to basic empty weight.

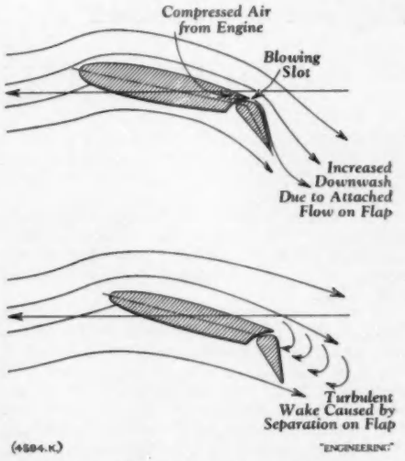


Fig. 10 The effect of "blowing" on the air flow over flaps. (a) Flap with supersonic blowing; (b) normal flap without blowing. Blowing over flap eliminates turbulent wake and results in increase of lift.

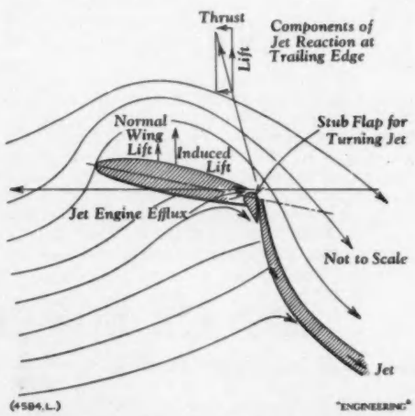


Fig. 11 The jet-flap principle. Deflected jet sheet acts as a flap and gives large increase of lift.

SUPERSONIC AIRLINERS

It was shown earlier that for conventional wing layouts the lift/drag ratio decreases rapidly at speeds above Mach 1, although there are ways in which the decrease can be modified. Fortunately, the higher speed gives higher engine efficiency and one may hope that structural efficiency will maintain the subsonic values; the loss of aerodynamic efficiency can therefore be partly counterbalanced, and the possibility of designing a supersonic civil airliner becomes of interest.

The direct operating cost of an aircraft is related to two items in particular, the basic weight of the equipped aircraft and the quantity of fuel used per trip. Increases in both are expected at supersonic speeds. Consequently, the direct cost per trip of operating the supersonic aircraft will, in the light of present knowledge, definitely be higher than in subsonic operation. The key to supersonic air travel is to obtain economic values of basic weight per lb. of payload and fuel weight per lb. of payload. We hope to do this by reducing drag, fuel consumption and structure weight at supersonic speeds, or by a combination of all three; there are, of course, exchange rates between these three. The longer the range, or the higher the supersonic speed, the greater will be the effect on the economics of operation of given percentage improvements in the items.

The present indications are that a supersonic airliner will need to carry a larger number of passengers than its subsonic predecessor if it is to allow an operating cost at all likely to attract even the luxury-class passenger. Take-off weight and size will be correspondingly larger. It is generally true that the interval between successive departures on any transport system, which successfully meets public demand,

* Paper read before the British Association, Section G, meeting in Dublin on September 9.

† Deputy Director, Royal Aircraft Establishment, Farnborough, Hants.

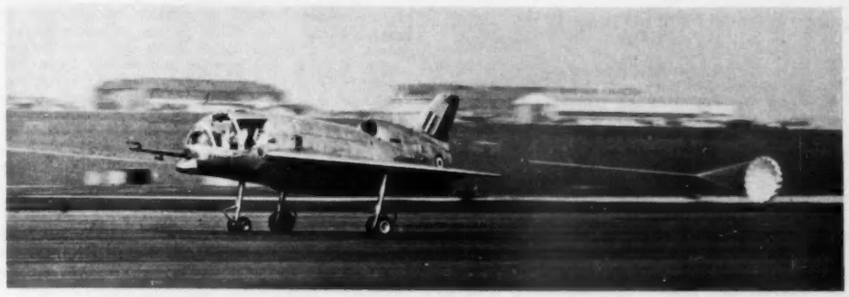


Fig. 12 Experimental vertical take-off aircraft.

is about equal to the travelling time on the journey. For example, one expects a bus journey of 15 minutes to have about a 15 minute service, and one does not expect departures from London to Istanbul by boat and train more frequently than one per day. For a given total passenger demand, the shorter duration of the supersonic airliner will therefore increase the demand for a more frequent service and thus delay the need for greater passenger payload per aircraft which is dictated by operating economy.

A further adverse factor is the greatly increased noise generated at take-off by large jet aircraft, not to mention the annoyance of sonic bangs. It may well be that some engine performance penalty must be accepted in the interests of noise suppression, and there are hopes that a combination of the by-pass type engine and corrugations in the jet pipe will give significant improvements.

In the quest for greater aerodynamic and structural efficiency at supersonic speeds, some strange shapes have been evolved, particularly for the low supersonic region up to Mach 1·2. The M-wing shown in Fig. 14 has considerable merit, but the narrow delta (Fig. 15) may still prove best for the higher speeds up to Mach 2 or 2·5. Whichever shape is adopted efficient civil operations will only be possible and economic if great improvements are made in methods of air traffic control, especially in the landing phase under marginal weather conditions.

One feels somehow that the main effect of supersonic travel on future passengers is likely to be below the belt! Having left London Airport at, say, 7 p.m. and dined in the gracious style of a B.O.A.C. "Super Monarch" service, it will be rather a gastronomic shock to discover on arrival in New York, 4½ hours later, that the local time is 6.30 p.m. and that an invitation to dine at the Waldorf Astoria is waiting at the passenger service counter!

Space Travel

Speculation on future trends in aeronautics would be incomplete without some remarks on space travel to which the prelude is being provided by the American and Russian satellite programmes and, unfortunately, also by the strenuous efforts to develop intercontinental ballistic missiles. In some ways the projection of an expendable satellite into an orbit is easier than that of designing an intercontinental bombardment missile; for example, the satellite does not need to survive re-entry into the earth's atmosphere. What the satellite does need is extra velocity, which could fairly easily be obtained by replacing the missile warhead by a further stage of propulsion and the final satellite, so one might expect satellites to be a by-product of the I.B.M. programme.

The propulsion of satellites and spaceships is best looked at in terms of the total energy increment required and the velocity to which this would correspond if it were all kinetic energy. The velocity v of a satellite in a circular orbit of radius r is given by equating centrifugal and gravitational forces: $\frac{v^2}{r} = \frac{gR^2}{r^2}$, where R is the earth's radius and g the acceleration due to gravity at the earth's surface. So the kinetic energy per unit mass is $\frac{v^2}{2} = \frac{gR^2}{2r}$. The potential energy increase in rising from the surface to orbital altitude is $gR^2\left(\frac{1}{R} - \frac{1}{r}\right)$. Adding this to the kinetic energy, the total energy requirement is

$$gR\left(1 - \frac{R}{2r}\right) \quad . \quad . \quad . \quad (1)$$

For a satellite at orbital altitude y, which is small compared with R, expression (1) becomes $\frac{gR}{2}\left(1 + \frac{y}{R}\right)$. So the velocity requirement for a satellite is approximately $\sqrt{gR}\left(1 + \frac{y}{2R}\right)$ . . . (2)

Now $\sqrt{gR}$ = 25,940 ft. per sec., so a typical

Fig. 13 The Hiller flying platform.

value of (2), for 300 miles altitude, is 27,000 ft. per sec. This is the velocity that a shell fired horizontally on the surface of an airless non-rotating earth would have in order to achieve an orbit equivalent to that of a satellite. (In fact, of course, the shell would have an elliptic orbit grazing the earth with a mean altitude of 300 miles, but a small impulse could convert this into a circle). Expression (2) also shows that changes in orbital altitude do not greatly affect the velocity required; increasing the orbital altitude from 200 to 400 miles increases (2) by only 3 per cent. At 200 miles altitude the speed of the satellite in its orbit is about 25,000 ft. per sec. The velocity for the satellite, relative to the earth's surface, can be reduced by 1,000 ft. per sec. or more if advantage is taken of the earth's rotation.

It may be worth emphasising that the satellite in its orbit is exempt from the severe heating problems which usually plague high-speed airborne vehicles. Aerodynamic heating is almost negligible at orbital altitude (200 miles or more) and the skin temperature of the satellite will generally lie between 175 deg. and 350 deg. K, the precise value depending on the surface finish, whether or not the satellite is in the earth's shadow, whether or not it rotates, etc. These temperatures are not very different from those of the earth's existing satellite, the Moon (120 deg. to 370 deg. K).

For space travel, expression (1) can still be used to give an idea of the energy requirements. Putting $r = \infty$ in (1) gives the energy requirement for escape from the earth's gravitational field as g R, corresponding to a velocity $\sqrt{2\,g\,R} \simeq 37{,}000$ ft. per sec., or about $\sqrt{2}$ times that for a near satellite. This "escape velocity" can be regarded as the minimum for interplanetary travel. A vehicle which attained it would just escape from the earth's field and move in a supine orbit as a new asteroid.

For more purposeful space travel the vehicle must have further energy at its disposal to cope with the gravitational fields of the sun and any other planets it may visit. The demands are best illustrated by plotting out the gravitational potential energy field of the solar system as indicated in Fig. 16 (not to scale), which covers the inner planets. Each planet is at the bottom of a gravitational "pit" and the escape velocity is proportional to the square root of

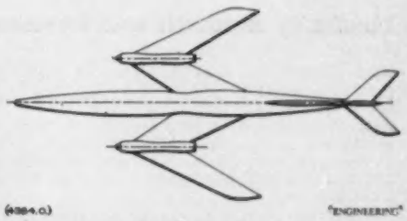


Fig. 14 The M-wing proposed for low supersonic speeds. Will the swept-back wing panels lead to the required aerodynamic efficiency?

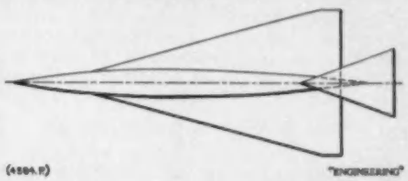


Fig. 15 The narrow delta wing. May be the most efficient shape for high supersonic speeds.

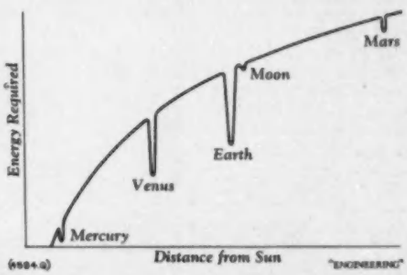


Fig. 16 Gravitational potential energy of the solar system. (Not to scale: the "pits" for the planets are much enlarged.)

the depth of the pit. (For clarity, the "pits" for the planets are much enlarged in Fig. 16, and the picture should not be taken too literally; climbing out of the pits is a satisfactory analogy, but the vehicle cannot "slide down" from earth to Venus, as the diagram might suggest.) After escaping from the "pit" an interplanetary vehicle would circle its parent planet, then at a suitable moment apply thrust for a short time to put it on a transfer ellipse bringing it into the vicinity of the target planet. There, a further application of thrust would place it on a circular orbit around that planet. Finally, there is the descent to the surface of the target planet, which would be made either by using the rocket thrust as a brake, or, more economically, by aerodynamic deceleration assuming a suitable atmosphere exists. Return to the parent planet would follow the same pattern.

Velocity requirements are (1) for escape, (2) for transit and (3) for descent, with a similar sequence on the return journey. For an Earth-Mars journey, typical requirements are 7 miles per second for escape, 1 m.p.s. extra for transfer and 3 m.p.s. for landing on Mars by thrust braking, giving a total of 11 m.p.s. for the outward journey or 22 m.p.s. for the round trip. If aerodynamic braking were feasible for the descents to both planets the requirement could be reduced from 22 m.p.s. to perhaps as little as 14 m.p.s., i.e., the total velocity requirement is two to three times the escape velocity of 7 m.p.s.

The performance requirements for satellite and space travel have been given in terms of velocity, because their feasibility depends on the essential ability of rocket engines to increase velocity, whether in air or *in vacuo*. The practical engineering question is, however, can this be done within reasonable limits of weight and size? A few simple formulae will illustrate the magnitude of the task facing would-be spacemen.

The velocity gained during the burning of a rocket is $V = gI \log\lambda$ where I, the effective specific impulse, gives a measure of the power of the rocket engine and λ is the ratio of the weight at launch to the weight at the end of the propulsion phase.

The space rocket will probably consist of a number N of stages, each with its own motor which lights up when the preceding stage burns out and drops off. If we assume that all stages have the same mass ratio λ, then $V_N = N\,I\,g \log\lambda$ and the ratio W of the weight at launch to the weight of the final

Continuing Research and Development

stage (destined to land on Mars) is given by $W = \left\{\frac{(1-\alpha)\lambda}{1-\alpha\lambda}\right\}^N$ where α is the proportion of each stage devoted to structure, motor, unburnt propellants, etc., i.e., the deadweight fraction.

Typical values for the various parameters, perhaps rather on the high side, might be $I = 250$, $\lambda = 5$, which give:—

$V = 26{,}000$ for $N = 2$, i.e. satellite velocity,
$V = 39{,}000$ for $N = 3$, i.e. escape velocity.

This last figure is the minimum necessary to start space travel. But what of W? If we assume $\alpha = 0{\cdot}1$ (10 per cent. for structure motor, etc., on each stage, which represents quite advanced design) then $W = 9^N$. So for the satellite the launching weight is at least 80 times the final orbiting weight, while for the minimum space ship the ratio is 700.

If, as so often happens in aircraft, the structure weight actually achieved in the prototype, as distinct from the design brochure, proves slightly heavy, say $\alpha = 0{\cdot}15$, then the launch weight of the minimum space ship rises by a factor of 7.

Some help can be gained from increases in rocket-motor performance as measured by the specific impulse I, but the maximum theoretical value with any propellents now known does not exceed 400, so there is little hope of spectacular improvement. Intensive development of military ballistic rockets may lead to a reduction in the structure weight parameter α, but it seems likely that fully fledged space vehicles will still be enormously large and costly. No doubt some form of flight refuelling may be evolved and nuclear propulsion offers interesting prospects. The problem of accurate space navigation remains, and the first space ship may justly write over the entry hatch "To travel hopefully is a better thing than to arrive, and the true success is to labour."

Acknowledgment.—The help of colleagues at the Royal Aircraft Establishment in the preparation of this paper, and especially of the diagrams and illustrations, is gratefully acknowledged. The views expressed are those of the author. All illustrations, other than Figs. 12 and 13, are Crown Copyright.

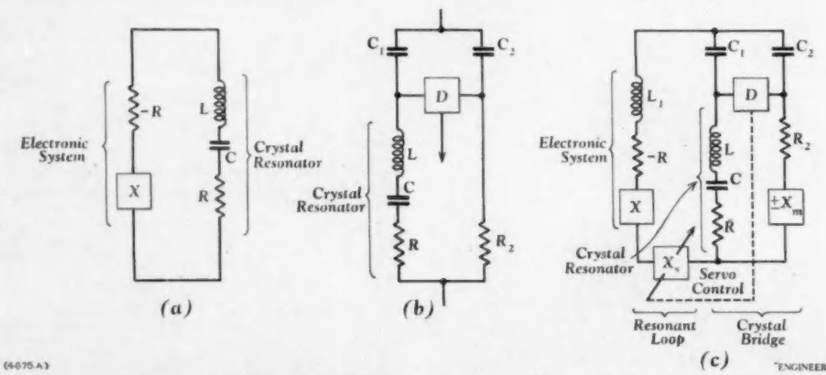


Fig. 1 (left) The quartz servo oscillator (c) can be considered as made up of the traditional type of crystal oscillator (a) and a radio frequency bridge (b).

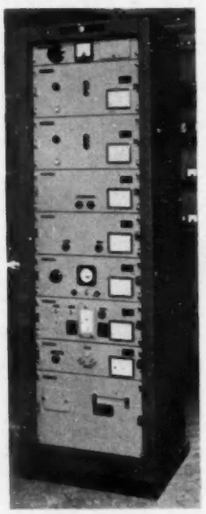


Fig. 3 (right) The complete oscillator equipment is housed in a single rack. The oven unit is behind the bottom panel.

INCREASING QUARTZ OSCILLATOR STABILITY

Recently on exhibition at the Western Electronic Show and Convention (WESCON) at San Francisco was the quartz servo frequency-standard equipment, type RD.101, manufactured by Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex. It provides what is believed to be the highest degree of stability so far obtained by quartz control in a production equipment.

The equipment achieves weekly stabilities to within 2 parts of 10^{10} and is therefore valuable in any field of activity where accuracy is essential —such as in observatories and research laboratories (where it can serve as an operational standard checked occasionally by an atomic resonance clock). Another application is as a master control of such navigational aids as LORAN and GEE.

The use of quartz crystals for the stabilisation of oscillators has been standard practice for many years past. But while frequency stabilities to within 1 part in 10^6 are commonplace in equipment used for broadcasting purposes, and orders of 1 part in 10^8 can be achieved without undue complication, there has been for some time a need for higher degrees of stabilisation. To this end research was implemented by the Marconi Company.

One prolific source of crystal instability is mechanical vibration, and this aspect was tackled first, resulting in the production of a 5 Mc/s crystal possessing a high degree of immunity from this trouble. With the mechanical vibration problem solved another major obstacle appeared. The adoption of a frequency of 5 Mc/s gave rise to instabilities caused by tube inter-electrode capacitances and cathode impedances. These combined to preclude a guaranteed stability to within 1 part in 10^9, the minimum requirement. Research aimed at eliminating valve and circuit effects led to the development of the principle of the quartz servo oscillator.

The development of the servo oscillator is shown in Fig. 1. Circuit (*a*) contains the fundamental elements of the traditional type of crystal oscillator: LCR represent the crystal at series resonance; $-R$ is the negative resistance needed to maintain steady oscillations; and X is an instability of reactance unavoidably introduced by the electronic system that generates the negative resistance. In order to eliminate this instability it is necessary to use a criterion for final frequency control that is independent of the electronic reactances and of instabilities of all possible circuit components. The most obvious criterion of this kind is a radio frequency bridge containing the crystal in one arm and highly stable passive linear elements in the others. Such a bridge is shown in circuit (*b*). By using adequate sensitivity in the detector D the resolution of bridge balance is extremely high and the output can be used to steer the operating frequency into alignment with the series-resonant frequency of the crystal.

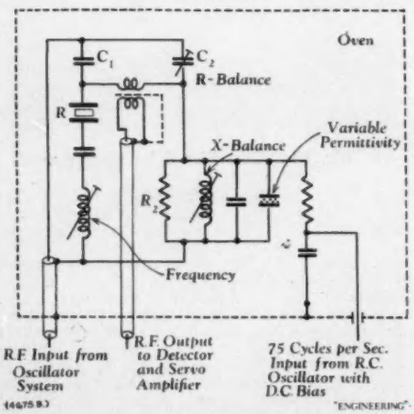


Fig. 2 The practical circuit derived from the quartz servo oscillator in Fig. 1 (c) is used in the Marconi type RD.101 oscillator, which has a stability of 2 parts in 10^{10}.

In order that the two forms of stabilisation may be used simultaneously, (*a*) and (*b*) are combined to form (*c*). The new arrangement includes three additional components: an inductance L_1 to balance the reactance of C_1 in the resonant loop; a periodically varying reactance $\pm X_m$ for the purpose of exploring the relation to bridge balance; and a correcting reactance X_s which may be controlled by an error signal from the detector D.

Fig. 2 shows how the bridge is connected in an oven, with fine adjustments for frequency, R-balance and X-balance. The effective modulating reactance, X_m of Fig. 1 (*c*), is got by 75 c/s voltage variations relative to a direct current bias on a capacitor having variable permittivity. The 75 c/s variation in the reactance in the R_2 arm does not significantly modulate the frequency of the system—the first sideband at 75 c/s separation is more than 100 dB down at 10 Mc/s.

The complete equipment is shown in Fig. 3, the crystal bridge being behind the bottom panel. Outputs are provided at 10 Mc/s, 1 Mc/s and 0·1 Mc/s. The power consumption is about 500 VA. An error of less than 1 part in 10^{10} occurs for a 5 per cent. change in supply voltage or 5 deg. C. change in temperature.

COMBUSTION ENGINEERING

The aims of the Combustion Engineering Association, whose headquarters are at 6 Duke-street, St. James's, London, S.W.1, are to further every possible means of increasing fuel efficiency in British industry, and to find a solution to the national fuel problem. As such, the Association is actively supported by many industries and also by the National Industrial Fuel Efficiency Service. The Association grew from the Coal Burning Appliance Makers' Association, which was formed in October, 1953, and membership is now open to all fuel users, consulting engineers, manufacturers, heating and ventilating engineers and those who are concerned with the distribution of solid or liquid fuels. This year there will be a conference at Harrogate on November 5 and 6, to study in detail the third report published by N.I.F.E.S., notes on which were given in our issue of October 4, page 427.

IMPROVING TELEPHONE COMMUNICATIONS

Post Office Research

Developments in materials, techniques and apparatus for long- and short-range telephony, radio, television and letter-sorting, were on view at the Post Office Engineering Research Station, Dollis Hill, London, N.W.2, at their recent open day. There were in all some 75 exhibits, and we propose in this brief review to confine ourselves to some of the major developments in telephony. Among these was a small example of the telephone exchange of the future—an electronic exchange for 200 subscribers capable of providing for 20 to 25 telephone conversations simultaneously over one pair of wires. In this system, time-division-multiple-pulse trains transmit both-way audio signals over a two-wire path without channel amplification.

SUBMARINE CABLES

Important developments are under way in long-range telephony, in particular a new type of lightweight submarine cable which is to be used, with two-way rigid repeaters at intervals to provide the necessary amplification, in a new transatlantic telephone link between Britain and Canada.

For over 100 years, deep-sea cable has been strengthened by winding a layer of steel wires around a simple cable of insulating material and copper. Cable of this type is in use on the first transatlantic telephone which has now been in operation for about a year. This method of construction is heavy and uneconomical in the use of steel; the cable also tends to twist when under tension and to form kinks under some conditions of laying or recovery.

The new lightweight cable has no external armour wires. All its strength is provided by a central core of non-twisting 110-130 ton steel rope with a copper conducting coating, the conductor being embedded in polythene insulation. Jointing of the core is effected by gripping each end of the steel wire in a steel ferrule to which a 50 ton load is applied.

Although the lightweight cable is much easier to handle than conventional cable, it cannot solve all the problems associated with laying a submarine cable equipped with a large number of rigid repeaters. The conventional method of controlling a cable when it is being laid by a cable ship is to pass three or four turns round a cylindrical drum or capstan, the shaft of which is equipped with a powerful brake. However, the modern two-way repeater is housed in a steel cylinder about 9 ft. long, weighing half a ton, and obviously it could not pass round a normal paying-out drum. The procedure usually adopted involves stopping the ship, taking the strain of the cable on a steel rope, removing the turns of cable from the drum by hand, moving the repeater past the drum on a trolley and then replacing the turns of cable, all of which is a lengthy, laborious and somewhat risky process.

The method now being developed by the Post Office substitutes for the cable drum a number of sheaves, coupled together mechanically and braked, over which the cable passes in a zig-zag fashion without making any complete turns. A steel by-pass rope is spliced to the cable at points ahead of, and behind, the repeater, so that when the latter reaches the laying gear, the by-pass rope replaces the cable on the sheaves and the repeater passes to one side in a slack loop of cable. A scale model showed how the equipment can be fitted on the after deck of H.M.T.S. "Monarch."

One of the problems met in the working of a long submarine cable fitted with many submerged repeaters is that of localising any cable or repeater fault that may interrupt or degrade the performance of the system. A new device for providing information about the repeaters has been developed at the Research Station. From one land-based terminal station a signal is transmitted along the cable and this causes one repeater to send back to the terminal station a signal from which the condition of the repeater may be deduced; by changing the transmitted signal, information may be obtained about each repeater on the route.

Transatlantic cables lying at depths of some 2,500 fathoms are subjected to pressures of the order of 3½ tons per sq. in. For proving the equipment at these pressures, the Research Station is equipped with two hydraulic cylinders, of 16 in. and 13 in. diameter, supplied by the English Steel Corporation and designed for pressures of up to 6 tons per sq. in. The water in these cylinders contains an inhibitor to prevent rust formation. Pressure is applied to the water by the standard shop supply of compressed air at 100 lb. per sq. in. and is stepped up by a pressure intensifier.

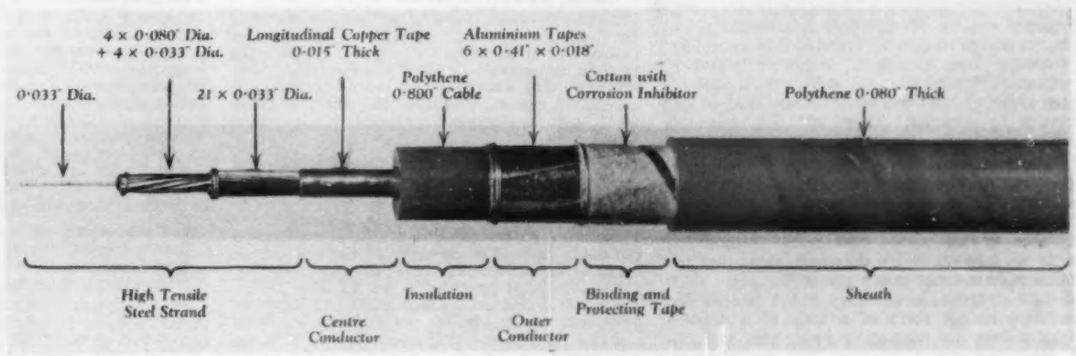
For proving trans-oceanic cables, hydraulic rigs provide for pressure tests up to 3½ tons per sq. in.

NICKEL-IRON MAGNETIC STRIP

Alloys incorporating nickel and iron as the main ingredients are used extensively in the telephone system, in the magnetic cores of coils and transformers. The development of components of reduced size and improved performance has led to a demand for alloys of a more consistently high quality, and in thinner sections, than manufacturers have hitherto been able to supply.

The magnetic quality is critically dependent on the proportions of the various metals in the alloy. It is difficult to maintain precise control of the composition at the high temperatures involved in the conventional process of melting and casting. Investigations at the Research Station have shown that the necessary control is more readily achieved by a powder-metallurgy process, in which the different materials, in the form of fine powder, are accurately weighed and then intimately mixed; the powder is converted into a solid billet, suitable for rolling, by compression and heat treatment.

Rolling and splitting machines capable of producing strip 0·00015 in. thick, completely free from edge burns, have been developed and techniques have been established for the heat treatment of the thin strip, so that its magnetic potentialities may be fully realised in use.



The new lightweight deep-sea cable has no external armouring and is based on a high-strength steel core wire.

Book Reviews

ASKING THE RIGHT QUESTIONS

System Engineering: An Introduction to the Design of Large-Scale Systems. By HARRY H. GOODE and ROBERT E. MACHOL. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y.* (10 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (75*s*.)

The title of this book is not an easy one for British readers to comprehend. The subtitle, "An Introduction to the Design of Large-Scale Systems," although apparently enlightening is not really much help, for the greater part of the book is an account of the statistical and mathematical techniques of operational research. The standpoint throughout is that the mathematical presentation is intended for engineering eyes and the operational research outlook, which pervades the whole book, is addressed to an audience of engineers employed in operational research and particularly devoting their attentions to what in this country is termed "analysis of requirements." Indeed, four-fifths of the book is devoted to probability, analogue and digital computers, and such subjects as queueing theory, games theory, linear programming, and so on.

The presentation of these subjects is done in a clear and stimulating manner. It is fair to describe it as vigorous but perhaps not always rigorous. The authors admit as much in their preface.

The authors' view that this is not a highly theoretical book is rather optimistic. Even more optimistic is their hope that "virtually all its contents can be comprehended with elementary calculus as a basis." This may be strictly true but anybody with only an elementary knowledge of calculus is going to have a very rough time in reading this book from cover to cover. Engineers who have had serious difficulty with their mathematical studies are advised not to try; those who enjoy a little mathematics will find the book very readable.

The stated objective of the book, "An Introduction to the Design of Large-Scale Systems," applies to the weakest part of it. Examples of large-scale systems given are mainly in the field of communications and defence. These examples are apposite and, in that part of the book concerned with exterior systems design, the authors have given what appears to be the first account in a text-book of analysis of requirements. They point out that before proceeding to the design stage it is desirable to define the objective. (They regard exterior systems design as statement of the problem and interior systems design as provision of suggested solutions.) Statement of the problem is much more difficult than is generally thought. The following set of questions—"How can the defence of the country be improved? How can the air defence of the country be improved? What is the best weapon system for air defence? What is the best missile system for air defence? What is the best missile system for the defence of an isolated installation against air attack? What is the best guidance system for missile A?"—are examples of the sort of questions that should precede writing of technical specifications and sketch design studies for types of defence against a specific form of attack. These six questions, important though they are, can be most misleading, although they will undoubtedly lead in due course to answers. They will not, however, necessarily lead to practicable answers.

The great weakness of this approach is that it does not acknowledge in its study of large-scale systems the existence of boundary conditions. The approach given can very well lead to a defence system whose cost would exceed the national income. This does not imply that the authors do not recognise some limitations. They discuss permissible solutions but a permissible solution in the form of a unit of a defence system does not necessarily imply that a multiplicity of such units makes a satisfactory system. Preliminary studies of what is the right technical specification for a designer must use measures of effectiveness, and the authors show very clearly how necessary it is to obtain the right measure.

Although the book devotes much space to operational research for engineers and acknowledges that in an operational research team there is usually a mathematician who understands these techniques, the authors' emphasis on the desirability of all members of the team understanding all techniques used is unreasonable. The book would have been much more manageable if the authors had in this instance confined themselves to providing an engineer's text-book on the techniques of statistics and mathematics used in operational research. That part of the book which deals with computers, on which there seem to be many suitable text-books already, could be omitted. At a later stage a separate book on the design of large-scale systems, confined to that subject and including analysis of requirements, giving references to the earlier book and the many standard works on mathematical techniques now available, would be welcome.

As a final comment the bibliography, deliberately kept short, is rather disappointing. It is not surprising that there is no reference to Churchman, Ackoff and Arnoffs' very recent book on operations research, but there is no mention of McClosky and Coppinger's *Operations Research for Management, Part II*. References to the American journal *Operations Research* and the British *Operational Research Quarterly* are lacking. In general the bibliography suggests that this work went to press about two years ago, and that the authors' reading has been rather limited in scope.

FROM QUANTA TO CRYSTAL PULLING

Semiconductors: Their Theory and Practice. By G. GOUDET and G. MEULEAU. Translated by G. KING. *MacDonald and Evans Limited, 8 John-street, Bedford-row, London, W.C.1.* (105*s*.)

This book differs from most other treatments of semiconductors in its wave-mechanical approach to the subject. To this end the first part, almost half the total length, is devoted to an introduction to the quantum-mechanics of solids. However, a considerable mathematical background is required if this section is to be understood, since the 125 pages devoted to it do not allow an elementary approach. On the other hand, although quite comprehensive, the subject matter is not adequate as a basis for theoretical research.

In the second part, which deals with the technology of semiconductors, a major change in presentation occurs, presumably traceable to the joint authorship. After a discussion on the various semiconductors, crystal pulling is described, and is followed by a chapter on physical measurements on the crystal. Fortunately, both this and the final part of the book can be read with little reference to the section on quantum-mechanics.

The final part, consisting of 117 pages, deals with semiconductor devices and is the most useful and well-balanced section of the book. It is, in fact, fairly complete in itself, and after a very short chapter on thermistors and varistors the bulk of the section is devoted to the preparation and processing of crystals, and the making of both point-contact and junction diodes and transistors. Although a few characteristics are given, circuit applications are not described. In the final chapter other semiconductor devices, such as photoelectric cells and infra-red modulators, are briefly described.

The book would seem to be most applicable to engineers, who could in general ignore the first part. The style and printing are of a high quality, unfortunately reflected in the price, and the book represents a very useful addition to semiconductor literature.

NEW BOOKS

Semiconductors. Report of the meeting held by *The Physical Society*, April, 1956. 1 *Lowther-gardens, Prince Consort-road, London, S.W.7.* (12*s*. 6*d*. to members, 20*s*. to non-members.)

The report contains 23 papers presented at the meeting on semiconductors held by the Physical Society, in collaboration with British Thomson-Houston Company, Limited, in April, 1956. Many of the papers have a list of references and the report will be of use to research workers. Most of the contributors are engaged in research work in English universities and industries, although there are contributions from the Netherlands, Switzerland, the United States, and Canada. Theoretical and practical aspects of semiconductors are covered.

Basic Mathematics for Radio and Electronics. By F. M. COLEBROOK and J. W. HEAD. *Iliffe and Sons Limited, Dorset House, Stamford-street, London, S.E.1.* (17*s*. 6*d*.)

Previously published under the title *Basic Mathematics for Radio Students*, this new edition contains new material contributed by Mr. J. W. Head. The elements of operational calculus and matrices (with not more than two rows and columns) have been introduced, together with a number of miscellaneous topics, such as numerical computation and normal distributions.

Modern Computing Methods. National Physical Laboratory Notes on Applied Science No. 16. *H.M. Stationery Office, Kingsway, London, W.C.2.* (10*s*. 6*d*.)

These notes on computation are based on lectures delivered by various members of the staff of the mathematics division of the National Physical Laboratory to representatives of industrial firms. The first four chapters discuss "algebraic" probiems —methods are included for use with desk machines and also with high-speed digital equipment. Chapter 5 introduces the theory of finite differences, used in chapters 6 and 7 to solve ordinary differential equations. Chapter 8 considers the solution of hyperbolic partial differential equations by the method of "characteristics," and chapter 9 discusses various methods of solving parabolic and elliptic partial differential equations. Relaxation methods are described in chapter 10. Tabulation and computation of mathematical functions are discussed and there are appendices containing a bibliography, an example of the use of Deuce, and a description of the mechanical differential analyser.

Receiving Aerial Systems. By I. A. DAVIDSON. *Heywood and Company, Limited, Ingersoll House, 9 Kingsway, London, W.C.2.* (21*s*.)

The book deals with receiving aerials rather than aerials that form part of a communication system. Some mathematical formulas relating to the performance of aerials have been given as a guide to evaluating specific problems—such as the magnitude of the signal received at the aerial. Detailed derivation of the formulas has not been given, in order to keep the mathematical analysis to a minimum. For the same reason, other theoretical analyses of aerial performance have been omitted. A chapter on measurements has been included to give an indication of some of the methods used. After an introduction to the subject, specific types of aerial are described and examples are given. Cables and accessories are discussed and so also are the problems raised by particular site conditions.

The Fundamentals of Electric Log Interpretation. Second Edition. By M. R. J. WYLLIE. *Academic Press Incorporated, 111 Fifth-avenue, New York 3, N.Y., U.S.A.* (4.50 dols.)

Electric logs measure the variations, in a borehole, of electrical currents which flow between shale beds and permeable beds; they also measure the resis-

tivity of the formations penetrated by the borehole. In addition to textual improvements, the second edition contains new sections on nuclear and acoustic logging; also a new chapter has been written on the treatment of abnormal spontaneous potentials. Two further sections of a less elementary nature than the remainder of the text have been added. These are "A general method of electric log interpretation" and "Log quality control."

American Institute of Physics Handbook. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y.* (15 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (112*s.* 6*d.*)

The handbook has been prepared by over 90 specialists and is intended to be of primary usefulness to the young scientific investigator and also to be of value as a reference work to the senior physicist. There are eight sections: mathematics, mechanics, heat, sound, electricity and magnetism, optics, atomic and molecular physics, and nuclear physics. Among the topics presented that are not easily accessible elsewhere are: geographical data, data on gels, tensile strength of liquids, fluid flow through porous materials, viscosity of suspensions, cavitation and diffusion in liquids; flow of gases—taking account of developments in aerodynamics, cross sections, fission products, health physics and mesons; properties of paramagnetic salts—with very low temperature data; high pressure effects; thermal conductivity at very low temperatures; new material, in the acoustics section, on analogies. The book should be of assistance to engineers and applied physicists.

Tables of Integrals and Other Mathematical Data. By HERBERT BRISTOL DWIGHT. Third Edition. *The Macmillan Company, 60 Fifth-avenue, New York 11, N.Y.*, (3 dols.); and *The Macmillan Company New York, 10 South Audley-street, London, W.1.* (21*s.*)

In this edition the following items have been added: two simple determinant formulas; some additional derivatives of inverse trigonometric functions; a method for extending the tables of e^x and e^{-x}; tables of trigonometric functions of hundredths of degrees.

★ ★ ★

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Steam Pressure Reduction and De-superheating. JAMES GORDON & CO., LTD., Dalston-gardens, Stanmore, Middlesex. Butterfly valves and needle valves for pressure reduction; the Gordon water-spray de-superheater for cooling steam which is too highly heated; and combined-duty valves for pressure reduction and de-superheating. Three illustrated technical leaflets (Nos. 140, 141, 142) describing components and associated control installations.

Educational Laboratory Apparatus. GRIFFIN & GEORGE LIMITED, Ealing-road, Alperton, Wembley, Middlesex. (1) The Griffin Raybox produces single or multiple light rays in white or colour for demonstrations in elementary optics. (2) The "force-on-a-conductor" balance for use in the direct measurement of the force on a conductor carrying a current in a magnetic field. Two illustrated descriptive leaflets.

Industrial Pneumatic Equipment. CLIMAX ROCK DRILL & ENGINEERING WORKS LTD., Redruth, Cornwall. Maxam valves and cylinders and their applications in tapping units, drilling machines, stamping machines, broaching machines, servo units, stacking machines, ball-race grinding machines, and tar-macadam mixing plant. Illustrated brochure.

Oil-Fuel Pumps. PLENTY & SON LTD., Eagle Iron Works, Newbury, Berkshire. Positive displacement variable delivery pumps for all grades of oil fuel from gas oil to extra-heavy, for pressures up to 200 lb. per sq. in. and temperatures up to 250 deg. F. Capacities: 200 and 500 gallons per hour. Illustrated specification leaflet.

Epoxy Resins for Tooling. AERO RESEARCH LTD., Duxford, Cambridge. "Araldite Resins for Tooling"—jigs and fixtures, press tools, drop-hammer dies, rubber-press tools, stretch blocks, vacuum forming tools, matched moulds and rubber-bag moulds, joggle blocks, hammer forms, router jigs, etc. Illustrated technical handbook.

Soil Mechanics Testing Apparatus. GRIFFIN & GEORGE LIMITED, Ealing-road, Alperton, Middlesex. Illustrated price list of testing apparatus for soil mechanics, bituminous materials, aggregates, sands and filters, plaster, lime and gypsum, concrete, cement, bricks and tiles.

Bursting Discs. THE DISTILLERS CO., LTD., Great Burgh, Epsom, Surrey. Metal-foil type bursting discs and holders for protecting pressure vessels. Available for pressures up to 25,000 lb. per sq. in. and for use in corrosive environments. Illustrated technical descriptive leaflet.

Relay for Liquid Level Control. MEAD & PHASEY LTD., Princes-street, Broadway, Bexleyheath, Kent. A.R.D. adjustable-range diaphragm relay for the control of both heavy and light liquids. Illustrated leaflet giving technical description and installation details.

Diesel Engines. RUSSELL, NEWBERY AND CO., LTD., Essex Works, Dagenham, Essex. "F" type Diesel engines, ranging from 43 to 160 b.h.p. Three, four and six cylinder models supercharged or normally aspirated. Leaflet.

400-Cycle Alternators. LAURENCE, SCOTT AND ELECTROMOTORS LTD., Norwich. 400-cycle salient-pole alternators for high-frequency applications. Technical details of construction. Outputs up to 200 kVA. Illustrated leaflet.

Geared Motor Units. LANCASHIRE DYNAMO AND CRYPTO LTD., Trafford Park, Manchester. Illustrations of geared motor units manufactured in outputs from 1 to 60 h.p. showing applications for a variety of purposes in the modern factory.

Threading Machines. MAIDEN & CO., LTD., Hyde, Cheshire. Details of a range of threading machines for bolts from ¼ in. to 3 in. A new heavy-duty model is included for threading tough materials such as stainless steel. Illustrated leaflet.

Air Hydraulic Power Feeds for Drilling Machines. W. J. MEDDINGS LTD., 16 Berkeley-street, London, W.1. Pacera Maxam power feed, and automatic disking machines and drilling heads equipped with Maxam units. Illustrated specification leaflet.

Mobile Conveyors. LAMSON ENGINEERING CO., LTD., Hythe-road, London, N.W.10. Mobile conveyors in capacities from 1 to 5 cwt. Illustrated specification leaflet.

On the Shelf

By Frank H. Smith

The Electrical Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey, publishes a journal called *Co-operative Electrical Research*, which formerly was available only to members of the Association but can now be bought at 2*s.* 6*d.* per copy. The papers in the third number before me appear to be chiefly concerned with heavy engineering. They deal, for example, with E.R.A. work on transformer and switch oils, and with the next stage in rural electrification research. The last paper, however, is on electronic engraving and this indicates the extent of the interests of the Association.

The *Unesco Monthly Bulletin on Scientific Documentation amd Terminology* for September 15 mentions the International Federation for Documentation's *Manual on Document Reproduction and Selection*. This is the Federation's publication No. 264 which has been produced with financial help from Unesco. Part I appeared in 1953 under the title *Reproduction*, and there were supplements in the following three years. Part II, entitled *Selection*, has been published this year and an index to this and the previous part, together with a supplement to Part II, will follow later in the year. Further particulars are obtainable from the International Federation for Documentation (F.I.D.), 6 Willem Witsenplein, The Hague, Netherlands.

In 1947 (so says the *Bulletin*) a Mr. B. Lampel read a paper to the Federation's 17th Conference at Berne on: "Une Technique Nouvelle de Classement des Fiches et des Microfilms." This has now been produced as a separate publication and can be obtained from Mr. Lampel at the Service d'Organisation "Synoptic," 150 Champs Elysées, Paris, 8e. It would seem that the "technique nouvelle" is particularly adaptable to "that of controlling the receipt and circulation of periodicals within an organisation, the titles, languages, subjects, countries of origin and circulation records of which are all indicated by coloured tabs."

The *Aeronautical Engineering Review*—the less "highbrow" of the American Institute of the Aeronautical Sciences monthly journals—for September, is interesting in that it celebrates the Institute's 25th anniversary. There is surprisingly little reminiscence but a blue insert lists the original 607 members. To-day there are 17,142 !

One of the reasons put forward for the numerical superiority of American technical books is that, in the United States, professors and other authors have more time to commit themselves to paper than is the case in this country of labour shortage and technician difficulty. A paper I have before me would seem partly to refute this. It is the quarterly lists of the published papers of members of the staff of the National Physical Laboratory. There are surprising numbers of papers appearing in a surprising number of periodicals representing the interests of the Laboratory's various departments.

The Institute of Metals now publishes a quarterly periodical, entitled *Metallurgical Reviews*, of which volume 1 (1956) has just been received. This is a bound volume of 522 pages and the reviews are intended to cover the whole field of metallurgy (in a manner to be understood by non-specialists) except mining, the extraction of metals from their ores and iron and steel works practice. This first volume contains 12 "reviews" by authorities in their various fields (not, I may add, confined to this country) and there can be little doubt that these, with the wealth of references at the end of each review will prove a boon to metallurgists and the libraries that serve them. The annual subscription, which is the only means by which the quarterly can be obtained, is 2 guineas and this includes a tasteful cloth binding case. Inquiries should be addressed to the Institute, at 17 Belgrave-square, London, S.W.1.

Quite one of the bulkiest publishers' catalogues that I have ever handled is that of the Librairie Dunod, 92 rue Bonaparte, Paris, 6e. As is clearly stated on the cover: "les livres d'enseignement font l'objet d'un catalogue special publié au debut d'avril de chaque année" and as "le présent catalogue" was "publié le 20 août," it does not, presumably, include "les livres d'enseignement." It still contrives to run to 756 pages and starts with an index that looks like a reprint, in French, of B.S. 1000. The main part of the catalogue is subject-divided, but here and there are pages of such items as "aides-memoires" which seem to be specialised volumes on such subjects as banque, bâtiment, exportation, matières plastiques, and métrologie, both générale and appliquée. Another nice little line are the manuels professionels pour le . . . and here they cater for le fraiseur mécanicien (milling machine operator); le fondeur; le garagiste; and many other trades and professions. The whole catalogue is a great temptation to a librarian with an unchecked budget and, if such there be, I should like to arrange to meet him sometime.

Everybody knows that the translation of technical material is one of the bugbears of modern technical progress. As though the obvious difficulties were not enough, Unesco have produced an exhaustive investigation of the subject in *Scientific and Technical Translating and Other Aspects of the Language Problem* in their "Documentation and Terminology of Science Series." This is no place to review such a learned treatise but a casual glance through the pages convinces me that I am a lucky man not to be concerned with translation. The price is 20*s.*, but it took me a long time to find it at the foot of the back cover.

Design

SIMULATING HELICOPTER FLIGHT

For training pilots in primary and advanced aspects of helicopter flying, practice of operational routines, emergency drills and instrument flying, a helicopter flight simulator designed by the research department of Short Brothers and Harland Limited, Belfast, is in an advanced stage of development. The simulator is intended ultimately to incorporate a computing system capable of simulating a wide range of aircraft, including both current and future types. It provides for varying weather conditions and for the introduction of emergencies such as complete or partial failure of the engine or other components. It can be used to simulate hovering, forward flight and autorotation, and transition from one to another of these conditions. The instrument may also be used for research into control and stability.

From the earliest stages of training the Short simulator enables the pupil pilot to see most of the sights and hear most of the sounds encountered in actual flying, and to experience many of the actual physical sensations. Seated in a full-size cockpit, which forms part of an abbreviated fuselage supported on a universal mounting, he becomes familiar with the actual angular motion of the aircraft in hovering and is able to " fly " at will over a three-dimensional landscape.

Servo motors on the two axes of the mounting enable the pitch and bank attitudes of the fuselage to be controlled according to electrical signals generated by the associated computing equipment in response to demands received from the pilot's controls. The angular movements of the cabin are sufficient to cover the normal attitude changes of a helicopter except, perhaps, in very steeply banked turns.

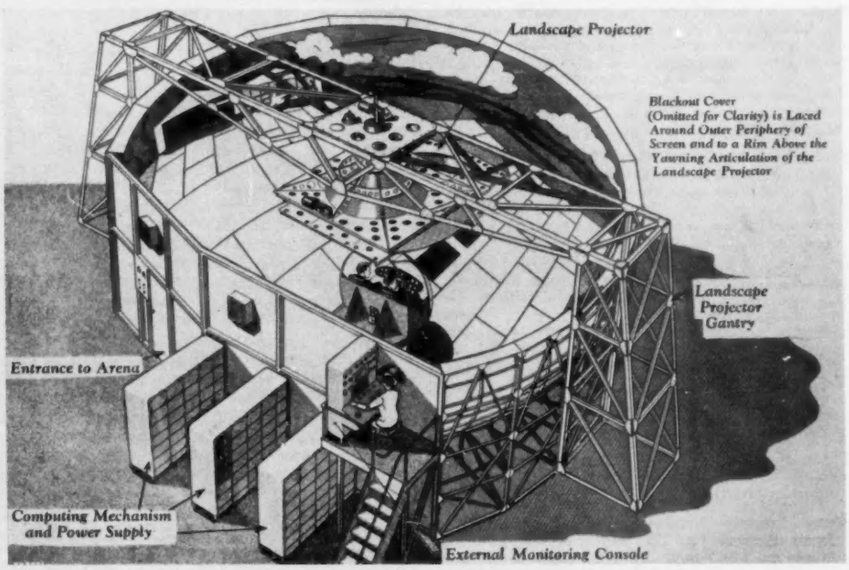
COMPOSITE LANDSCAPE

Apparent freedom in azimuth is unlimited. The yawing oscillations are not applied to the cabin itself, but the change in heading is represented by traversing a colour image projected on a curved screen surrounding the cabin. This image gives the pilot the impression of being surrounded by a landscape stretching to the horizon. The image used is a composite one cast by two projectors which are linked together in their yawing motions. One, a horizon projector below the cockpit, casts an image of the sky above the horizon line and of the land or sea below it. The horizon remains always above the level of the pilot's eye.

The second, or landscape projector, is situated above the pilot's cockpit. It throws on the screen the image of a landscape of limited area blending into the horizon image. The landscape includes three-dimensional objects, such as hangars and trees, and some of these are projected above the horizon when the aircraft is supposed to be at ground level. The landscape image is traversed in the ground plane according to the computed motion of the aircraft and both images are rotated about the cockpit in agreement with yawing motions. When the aircraft changes height the scale of the landscape image is changed appropriately, and during all motions the perspective views of the three-dimensional objects change so that the pilot receives a realistic impression of his movement relative to them.

The landscape permits flights by visual reference within an area of 360 yards diameter and up to a height of 400 ft. enabling the pilot to make auto-rotative descents from " safety heights " to suitable emergency landings. Heights up to the ceiling of a particular aircraft type can be simulated, however, with appropriate instrument reading and control response. The landscape shows a landing strip of concrete about 150 ft. long, with hangars, windsock and the usual markings of a " heliport " surrounded by typical countryside with trees and occasional buildings. The projection screen surrounds the cockpit through 230 degrees in azimuth and can be made in dismountable sections.

The cockpit is fitted with typical controls for collective pitch and throttle, cyclic pitch and yaw, arranged in standard positions. The cockpit rocking mechanism is capable of rotations of $\pm$ 30 deg. about each of two axes at right-angles, but is limited to $\pm$ 24 deg. in pitch for space reasons connected with the projection. system. The rotations are controlled by two electro-hydraulic servomechanisms which provide a cockpit attitude in the form of a voltage signal proportional to that demanded by the computing system. These high-response servomotors are capable of providing angular rates to the cabin of $\pm$ 1·2 radians per second. The electrical cables and the hydraulic pipes for the cabin actuation, instruments and services are led up inside the central pillar of the supporting pedestal. The hydraulic-pressure supply for these servomotors is obtained from a high-pressure pump set housed in the base of the pedestal and operating on 230 volt 50 cycle mains electricity.


Landscape Projector
Blackout Cover (Omitted for Clarity) is Laced Around Outer Periphery of Screen and to a Rim Above the Yawning Articulation of the Landscape Projector
Landscape Projector Gantry
Entrance to Arena
Computing Mechanism and Power Supply
External Monitoring Console

In the Short helicopter flight simulator, the pilot, seated in a universally mounted cockpit, experiences most of the sensations of flying as he operates the controls.

PROJECTORS

The projectors operate on the " Linnebach " or shadowgraph principle, using a specially designed filament lamp as a small concentrated light source to cast the shadow of a colour transparency on the screen. In the case of the horizon projector, showing a distant view which is unchanged in perspective by the pilot's apparent movements, the transparency is a two-dimensional picture on a cylindrical surface with a fixed lamp on the axis of the cylinder; the latter can be yawed about its vertical axis by an electrical servo, according to the computed heading of the aircraft. The transparency is painted to represent a comparatively featureless landscape or seascape viewed from a moderate distance; there is a level skyline with a few distant landmarks to serve as reference points. Alternative transparencies are available and can be changed in a few minutes.

The landscape projector, however, employs a semi-transparent model containing objects whose images change their perspective relationships with the apparent motion of the aircraft. The reason for the illusion created is that the rays of light emanating from the point source lamp over the model follow the same path as would the lines of sight of a pilot in a scale model aircraft occupying the position of the lamp. If these rays are caught on a screen surrounding the lamp the image produced, viewed from a point close to the lamp, shows the true perspective of the landscape as the pilot would see it. Consequently, if the model is moved in relation to the lamp the image on the screen will reproduce the perspective changes seen by the pilot when carrying out equivalent manoeuvres. While it is impossible for the pilot's eye to coincide with the lamp, experience has shown that appreciable vertical separation between the pilot's eye and the lamp can be tolerated without noticeable distortion of the image. The projectors are in any case designed to minimise such distortions as these.

The landscape projector is mounted above the cockpit. It consists of a circular three-dimensional transparent colour landscape model, 9 ft. in diameter to a scale of 10 ft. to 1 in. It is mounted on a carrier running on rails which permit translation along the north-south axis of the model. These rails are in turn carried on a pair of rails at right-angles permitting translation along the east-west axis. The entire assembly is mounted in a circular bearing that permits unlimited yawing. The lamp can be moved from a position close to the plate—giving a scale height of about 8 ft.—to a scale height of about 400 ft., the movement being controlled by vertical speed signals from the computer. The movements of the model are operated by electric servos controlled by velocity signals from the computing system.

ANALOGUE COMPUTER

This system is a network of electronic and electro-mechanical units which are interconnected so as to solve by analogy the various simultaneous equations of motion which represent the behaviour of the helicopter. In the main the computing channels consist of integrating and adding units together with a number of multiplier units for product formation, function generators to represent non-linear characteristics, and resolvers for trigonometrical operations.

The computer is fed with electrical imput signals derived from potentiometers coupled to the cyclic and collective pitch controls, rudder bar and throttle twist-grip, and generates output signals representing aircraft attitude, rates and translation which are fed to the projector and cabin servos and the simulated instruments. Various subsidiary computing loops are provided to represent the effects of variation of air density and pressure with altitude, the develop-

ment of induced flow in the various regimes of rotor operation from the wind-mill-brake, through auto-rotation to the propeller working state, and the influence on this of forward flight and of the proximity of the ground.

Noise-generating circuits monitored by the engine and rotor-speed computing servos synthesise the sound and the vibration of the rotor and engine. In addition, a " rough air " generator can be coupled into the aerodynamic block as required by the instructor, who can also vary the sea-level air density in order to simulate the effects of climate on performance.

Controls at the disposal of the instructor, both at his external monitoring position and on a panel on the left side of the cockpit, provide for the sudden imposition of emergency conditions such as complete, partial or progressive cessation of engine torque, increase of rotor drag torque (as, for instance, in icing conditions) or deficiency of tail-rotor torque such as might be experienced if the tail rotor struck an obstacle or otherwise failed.

The basic computing unit is a high-gain direct-current drift-corrected amplifier with low inherent phase shift. It is constructed as a flat assembly with an integral handle and normally ten of these can be plugged into one 19 in. panel. For cheapness and consistency of performance, printed circuits are employed wherever possible. According to the feedback network connected across it, the standard amplifier can be employed for addition, high-speed integration, and various other functions. For slow-speed integration and multiplication, for function generation and resolution, the basic amplifier is used to drive an instrument-type motor generator with a high torque/inertia ratio coupled to low-friction potentiometers so as to form either a velocity or position control servo mechanism.

Fuel pipes in the boiler house.

HIGH PRESSURE STEAM PLANT

240 MW Meaford B Power Station

The 240 MW Meaford B power station, which forms part of the generating capacity of the Midlands Division of the Central Electricity Authority, was formally opened by the Lord Lieutenant of Staffordshire (Mr. H. Wallace-Copland) on October 4. It is situated 8 miles south of the Potteries between the River Trent and the Trent and Mersey Canal, and was designed and constructed under the supervision of the chief engineer's department of the Authority with Messrs. Merz and McLellan and Sir Alexander Gibb and Partners as consulting engineers. The station has been in partial operation since November, 1955, and it is expected to be completed by the end of 1957.

CONSTRUCTIONAL DETAILS

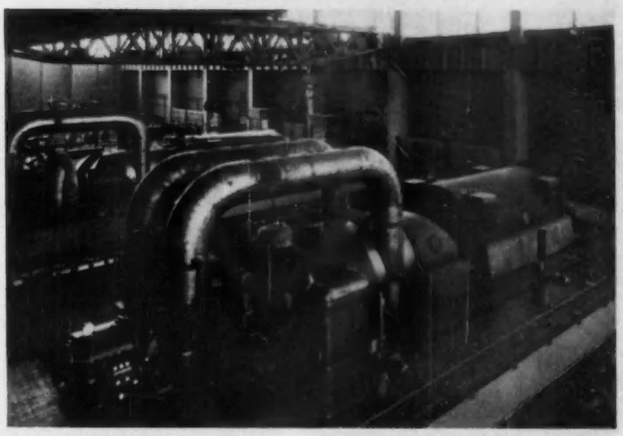
The area on which the main buildings are erected formed part of a hillside which had to be excavated. As a result there is an embankment round three sides of the site on which the sidings and coal tipplers are located. The reinforced-concrete foundations of the boiler house are laid direct on rock, but piling was employed for those of the turbine house and cooling towers. The buildings are generally of steel-frame construction with brick cladding and the main building, which is 290 ft. long by 297 ft. wide, is in two sections which house the boilers and turbines with their associated equipment, respectively, there being no dividing wall between them. The control room is on the top floor of a separate four-storey building, which is reached by a footbridge from the turbine room and also contains the offices.

GENERATING PLANT

Coal is brought to the site by rail and is discharged either on to duplicate conveyors leading to the boiler house bunkers or on to a single conveyor to the store, the capacity in each case being 200 tons per hour. It can be withdrawn from the store to the boiler house by another conveyor with a capacity of 400 tons per hour. From the boiler house bunkers, each of which has a capacity of 1,100 tons, the coal is discharged into the pulverisers of which there are four for each boiler, three being normally in service. The fuel pipes installed for this purpose are illustrated above.

The boilers themselves are of the radiant single-drum suspended type and each has a continuous maximum rated output of 515,000 lb. of steam per hour at a pressure of 1,600 lb. per sq. in. and a temperature of 1,065 deg. F. The furnaces, which are water cooled, are divided into two sections by a central vertical wall of tubes and have eight burners in the roof. Associated with it are primary and secondary superheaters, economisers, forced and induced draught fans and electrostatic precipitators, the gases being finally discharged into a single 400 ft. chimney. Combustion is controlled by automatic equipment so that the rated boiler pressure and temperature are maintained at any steam output. Operation is on the unit principle, there being no interconnections between the boilers and turbines on the steam and water sides, except for an emergency cross-over on the feed system.

Ash from the boilers and precipitators is discharged by a high-pressure water-sluicing system through a crusher to a sump and is then delivered through a pipeline by pumps to one of two settling ponds on the eastern half of the site. As one of these ponds is being filled the other is excavated and the ash is finally transferred to the required area, from which the top soil has been temporarily stripped, by dumpers.



One of the 60 MW turbo-alternators, showing steam inlet pipes.

The four 60 MW turbines, one of which is still in course of erection, are of the two cylinder combined impulse-reaction type with double-flow low-pressure cylinders exhausting to twin condensers. The steam inlet to the high-pressure cylinder is adjacent to the low-pressure cylinder, as shown above, there being two steam chests, which are connected by transfer pipes. Double-casing construction is employed in the high-pressure cylinder, the inner casing being of austenitic steel. A radiation shield to limit thermal stresses and distortion is provided between the two casings. Electronic supervising gear is fitted for indicating and recording eccentricity and differential expansion in the high-pressure cylinder.

The alternators, which generate three-phase current at 11·8 kV and 50 cycles are hydrogen-cooled at a pressure of 0·5 lb. per sq. in., while the direct-coupled double unit exciter is air-cooled. The stator frame is of welded steel and has been designed to withstand the maximum pressure developed when the most explosive mixture of air and hydrogen is ignited inside it.

Cooling water is circulated by four pumps, each with an output of 2,400,000 gallons per hour against a head of 55 ft. After passing through the condensers, this water is delivered to three cooling towers, each of which can deal with 3,150,000 gallons per hour. Make-up water is obtained either from the River Trent or from adjacent sewage works. The condensate is heated in six stages to give a final feed-water temperature of 400 deg. F. at maximum load. Each boiler is supplied from one feed pump with a stand-by pump per pair of units. These pumps are all electrically driven and have an output of 567,000 lb. of water per hour against a pressure of 2,000 lb. per sq. in.

ELECTRICAL ARRANGEMENTS

Each generator is directly connected to a 72 MVA 11·8/132 kV transformer, the output of which is taken to an outdoor substation where bulk oil circuit-breakers with a rupturing capacity of 2,500 MVA are installed. These circuit-breakers are operated from the same control room as for the A station. The auxiliaries are supplied either from the substation through two 10 MVA 132/3·3 kV station transformers or from 6MVA 11/3·3 kV unit transformers, one of which is directly connected to each generator. Supplies for essential auxiliaries are obtained from an auxiliary transformer of which there is one for each boiler-turbine unit, while the general auxiliaries and coal and ash handling plant are supplied at 415 volts from other transformers. Both the 3·3 kV and the 415 volt switchgear is of the air-break type.

The principal contractors engaged in the construction and equipment of the station were: G. Percy Trentham Limited, Birmingham, and the Cleveland Bridge and Engineering Company, Limited, Darlington, for civil engineering work and buildings; Babcock and Wilcox Limited, London, coal and ash handling and boiler plant; British Thomson-Houston Company, Limited, Rugby, turbo-generators and generator and station transformers; Brush Engineering Company, Limited, Loughborough, auxiliary transformers; Hick Hargreaves and Company, Limited, Bolton, feed heating and condensing plant; Mather and Platt Limited, Manchester, boiler feed pumps; Davenport Engineering Company, Limited, Bradford, cooling towers; W. H. Allen Sons and Company, Limited, Bedford, circulating water pumps; General Electric Company, Limited, London, 132 kV switchgear; A. Reyrolle and Company, Limited, Hebburn, auxiliary switchgear.

Production

ROLLING ALUMINIUM TO 0·005 MM.

Fig. 1 Four new rolling mills, each with duplicated coilers, have been installed for the early reduction of aluminium strip.

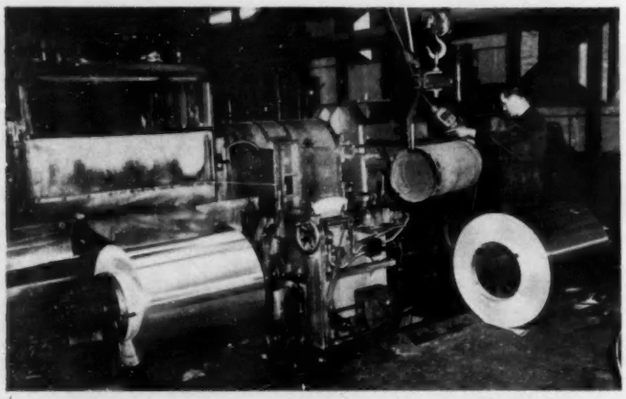
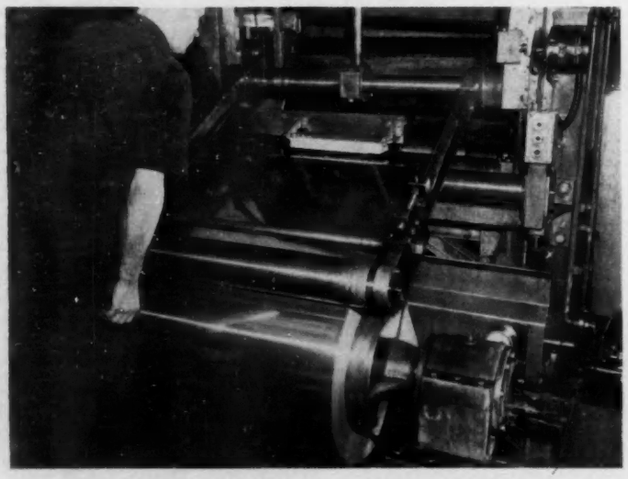


Fig. 2 While one reel is in use, the second is being loaded. The coiler unit is traversed by hydraulic power.



ONCE, not so long ago, "silver paper" was a novelty; now, the range of uses is enormous, including such diverse items as cigarette wrappings, electrical condensers, and roof insulation. Also, nowadays, it is almost invariably made of aluminium.

To meet this ever-growing demand for foil, Venesta Limited, Vintry House, Queen-street-place, London, E.C.4, have installed four new rolling mills at their Silvertown works. They were formally started up on September 20 by Sir Thomas Williamson, C.B.E., J.P., the secretary of the National Union of General and Municipal Workers.

The new mills, which are illustrated in Fig. 1, are of the two-high type and were supplied by W. H. A. Robertson and Company, Limited, Bedford. They will roll foil up to 30 in. wide and down to 0·05 mm. thick. Their combined output is 3,500 lb. of foil per hour, or about 500 ft. to 800 ft. per minute. It is intended to use the mills for the first three passes only, the final reduction being carried out on existing machines.

From the technical standpoint, the mills have four outstanding features:

(i) A coil loading and unloading system, which permits the mill to roll while the next coil and spool are loaded into position;

(ii) The use of alternating current motors and switchgear for the mill and coiler drives;

(iii) The use of radio-active isotope gauges to give the operator an instantaneous accurate foil measurement as the coil is being rolled; and

(iv) A centralised rolling-oil station common to all four mills, where the oil is cleansed and conditioned.

Loading System

The loading system, which is an integral part of the new mills, was devised entirely by Venesta, who believe they are the first company to apply the system to foil rolling mills. The principle of a double-loading system which can move into the operating position, however, is already used extensively in the machine-tool and other industries.

The unwinding and re-winding coilers, on which the coils are mounted, are therefore arranged in duplicate (see Figs. 1 and 2). They are moved hydraulically opposite the rolls as required and, as one coil is being rolled, the previously rolled coil and empty spool can be removed from the duplicate stations and a new coil and spool placed in position ready for rolling. As soon as the coil being rolled is finished, the new coil and spool moves into position and the cycle is repeated. A Haskins Rolador shutter is used to cover the trench in which the complete loading assembly moves.

Driving Motors and Switchgear

Another noteworthy feature of the new mills is that a.c. equipment is used for both the main and coiler motors. This installation was designed and manufactured by Laurence Scott and Electromotors Limited, Norwich, in collaboration with Venesta and is an extension of less complete mill drives previously used by Venesta and built by the same company. Although the main a.c. driving motor has a wide variable speed range, as required for operating purposes, use is made of frequency converters to drop the frequency to a very low figure to provide a low "threading-up" speed and to start the mill from rest—all this being done through the one main driving motor.

A system of loading the foil by pneumatic cylinders to produce a known constant tension is used to give an over-riding speed control on the a.c. coiler motors, which are primarily synchronised with the main mill motors. The degree of tension required by the foil is selected by the operator. A floating roll, running on the winding-up coil adjusts the speed of the coiler motor so that the linear speed of the foil remains constant. This roll (which is shown in Fig. 3) operates through a Variac.

Fig. 3 (left) The speed of the winding reel is governed by the floating roll resting on the coil. Variations in foil thickness are indicated by the beta absorption gauge.

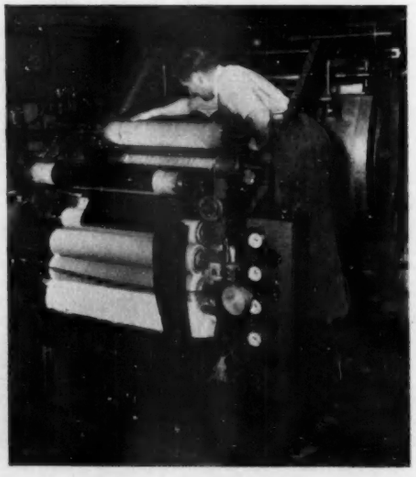


Fig. 4 (right) For some purposes the foil is backed with paper and the two bonded with an adhesive. Each roll in the machine is driven by a hydraulic motor.

Thickness Control

A radio-active isotope thickness gauge, made by the Baldwin Instrument Company, Limited, Brookland Works, Dartford, in conjunction with the firm, is mounted over the foil when it leaves the rolls. It can be seen in Fig. 3. Any variation in foil thickness is immediately indicated on an instrument on the operator's control panel and any necessary corrections made by altering the mill speed.

Rolling Oil Installation

During rolling, oil must be flooded on to the rolls to control roll profile and give the necessary lubrication to produce a reduction in thickness.

A constant supply of oil is available from an underground rolling-oil installation, which has been specially built to feed the new mills. Oil is continually circulated to the mills and back to the tanks, being cleaned by Autoclean strainers supplemented by a by-pass Fuller's Earth filtration system installed by the Paterson Engineering Company, Limited.

FOIL PROCESSING

As was said earlier, the new mills are only being used for the first three passes. For the final reduction, two layers of foil are rolled at the same time in four-high mills, a procedure rendered necessary by the extreme thinness. (Foil only 0·005 mm. thick is sometimes used for condensers.) To enable this to be carried out, two coils of foil are rewound as a pair and, after rolling, another machine is required to separate them. The final thickness depends on the end purpose for which the foil is intended, and ranges from 0·45 mm. downwards. Naturally, for the finer gauges, the surface finish of the rolls is vital.

Aluminium is a material which work hardens quickly, and consequently the foil has to be annealed between passes. This is done in either semi-continuous or pit EFCO ovens and has the added advantage that the temperature at which it is carried out—400 to 500 deg. F.—sterilises the foil. In general, standard spools are annealed in the semi-continuous ovens, and spools of unusual weight or size in the pits. It is important that each loading should contain spools of only one gauge of foil.

Much of the foil used for packaging is required to be embossed, printed, coated or laminated, or any combination of the four. Coatings—mainly of nitro-cellulose and vinyl or other synthetic resins—are flooded over the foil by an application roller and subsequently dried as the foil passes over steam-heated drums. The evaporated solvent is exhausted through hoods and subsequently recovered with a loss of only about 30 per cent. Recovery is carried out in a separate building where the mixed vapours are first condensed and then separated in a column. Printing can be carried out in four colours by the aniline process. (The gravure process is used at the other Venesta factories.) By laminating is meant the backing of the foil with another material, such as paper or parchment, as is required, for example, for wrapping cigarettes or butter. The backing adds rigidity and strength to the foil. Water-based gums, emulsions or molten adhesives, such as paraffin wax, are used to bind the foil and backing. A machine applying the adhesive is shown in Fig. 4. It is interesting to note that the rolls are separately driven by hydraulic motors.

Running transversely across the output ends of all the lines in the processing department, is an electrically-driven weigh truck which takes the completed reels, weighs them and passes them through to the final stages. At all stages some trimming of the sides of the reels is required, and therefore a certain amount of scrap is produced. This occurs particularly in the final slitting and reeling, where definite widths of strip are required.

For many wrapping purposes, foil is required in reels of stated width. These are produced in slitting and reeling machines, one type of which is shown in Fig. 5. This particular machine has a photo-electric guide which corrects for any misalignment of the foil and so ensures that the slitters do not cut into the printed pattern. Double winding heads using surface pick-up take up alternate sections of the slit reel. In some machines an embossing roll is included, so the three actions of embossing, slitting and reeling are carried out in the single unit. Alternatively, the embossing is carried out in an earlier process.

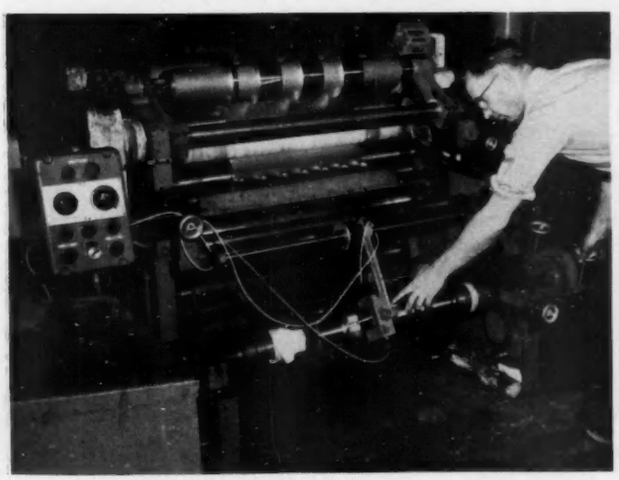


Fig. 5 Finally, the strip of foil is slit into the required widths and coiled. A photo-electric device relates the position of the slitters and the printed pattern.

CURBING VARIETY IN ELECTRONIC COMPONENT PRODUCTION

The number and complexity of electronic equipments increase rapidly. Conditions of operation become more varied too. This is particularly noticeable in the equipment of the armed forces. In airborne equipment, for example, temperatures may vary between − 80 and 400 deg. C. or higher; humidity and fungi become additional hazards in tropical environments; and noise and vibration can reach intense levels in the equipment bays of jet aircraft. Yet a piece of complex equipment is only as reliable as its most unreliable component. And the greater the number of components the more reliable must each component be.

However, the meaning of reliability varies too. A guided missile requires full use of its components for a few minutes at the most, while an amplifier in a submarine cable needs components that perform consistently for many years.

Many times, the designer of a particular piece of equipment may be tempted to specify individual components for his equipment, designing them for their special purpose. However, the stores and servicing problems that result from such a procedure are formidable, while production techniques rapidly become uneconomic.

To take advantage of mass production, and to aid storing and servicing, it is necessary to standardise components. The standardisation must take account of the variety of environments and functions of modern equipment; and the present rapid rate of advance in the components themselves makes the task more difficult.

In such a situation, the International Symposium on Electronic Components recently held at the Royal Radar Establishment, Malvern, was most valuable. For as there are about 190 companies in Britain alone producing components it is essential that engineers working in this field should get together to discuss mutual problems and new developments. Further advantages accrue by making the symposium international. Some 27 papers were read describing developments in a variety of components and suggesting new production techniques.

In a paper, "Problems affecting the design of service components and a survey of present and future United Kingdom developments," Mr. G. W. A. Dummer, of the Royal Radar Establishment, Malvern, emphasised the need for rationalisation in the production of components. During the period 1939-45 the production of electronic components trebled, but the rate of increase was slow. As a future war would allow only a very much shorter period for a similar stepping up of production, it was essential, he concluded, that rationalisation should be carried out now. Mr. Dummer mentioned that a general classification was being considered in which components were to be divided into general classes: airborne, ground, ship, and guided missile, each of which has a separate category for transistorised equipment. Further subdivisions specify humidity, temperature, vibration, life, pressurisation, and nuclear radiation.

As an example of how unchecked variety in production can lead to problems, Mr. Dummer stated that in the United States in 1956 there were 218 different types of transistor available, whereas far fewer would satisfy most needs.

★ ★ ★

HAND OR MACHINE LAPPING

A new range of lapping products, available in the form of wheels, stones, hand laps and paste, is now being marketed by the B.P.S. Machinery and Spares Company, Limited, 245 Knightsbridge, London, S.W.7, under the name of "Macolaepp." The material has a hardness of 9·5 to 9·8, taking the hardness of diamonds as 10, and the cost is considerably less than that of diamond-impregnated laps.

Three different types of lapping wheel are available in a wide range of sizes, chiefly for lapping carbide-tipped and high-speed steel tools. Macolaepp wheels, for which a very long working life is claimed, are usually run dry, but water is used for cooling when heating is experienced; turpentine can be used if a finer finish is required. Owing to the high density of the grain layer, the wheels are run at a slower speed than other types, a surface speed of 1,500 ft. per minute giving the best results. Lower speeds give greater abrasion and higher speeds a finer finish.

The Macolaepp hand lap has a working surface of 0·8 in. by 2·4 in., and is 0·4 in. thick. It is provided with a convenient handle. For sharpening profile tools, lapping stones are made in various sizes, and of circular, semi-circular, triangular, square, and rectangular section.

All the wheels, hand laps and stones are manufactured with grain sizes ranging from 25 to 130 microns. Paste can be supplied in the same grain sizes, and also in a special range from 1 to 10 microns in size for use on soft materials. It is supplied in concentrated form.

Atomic Review

Double Feature

PEOPLE prepared to spend money do not believe that the nucleus has revealed all its secrets yet. Every issue of *Physics Abstracts* contains scores of items disclosing new details of nuclear structure; and thousands, if not millions, of pounds, dollars and roubles are being spent on particle accelerators yearly. Much has been said and written on thermonuclear fusion, but it would be surprising (in view of all this research) if some far simpler means of extracting energy from the light nuclei were not some day discovered. It may be supposed that only the most highly rated accelerators can lead to striking practical results of this kind; but, in fact, useful information is being gathered daily at all particle energy levels. An interesting system for accelerating particles by means of tandem electrostatic generators is described below.

Tandem Electrostatic Generators

The United Kingdom Atomic Energy Authority has requested Metropolitan-Vickers Electrical Company, Limited, to collaborate in the design of two tandem electrostatic generators for use at the Atomic Energy Research Establishment, Harwell, and the Atomic Weapons Research Establishment, Aldermaston. The major parts of these machines will be made at the company's Trafford Park Works. They will enable research to be carried out into the nuclear properties of uranium and similar elements and will provide energetic neutrons for other nuclear work.

Compared with the familiar Van de Graaff accelerator the tandem generator has the novel feature that acceleration is achieved in two stages. Negative hydrogen ions are first accelerated from earth potential to an energy of 6 MeV. They are then fired into a "stripper," which removes the electrons from the outer shells of the atom and leaves the ions still moving in a forward direction with a net positive charge but with energy almost unchanged. The second stage of acceleration is achieved by bringing the positive ions back to earth potential, so that the total energy communicated to the ions is 12 MeV. In this way, ions are accelerated to an energy twice as great as could be achieved in a single stage whilst the insulation problems are exactly the same as in a single-stage machine. As a general rule, negative ions are more difficult to form than positive ions, and therefore the beam current in a tandem machine is smaller than in a single-stage machine, but this is a small price to pay for the saving in insulation.

Some idea of the engineering problems involved in the design and construction of a tandem generator of this type may be obtained from the following details. The generator is housed inside a pressure vessel 45 ft. high and 9 ft. in diameter, which contains an insulating belt mounted on pulleys some 16 ft. apart. The belt moves at 3,000 ft. per min., and electric charge sprayed on to its lower end is carried to the central terminal where the charge is collected. The charge leaks back to earth through two potential divider chains, one going to the lower and one to the upper end of the vertical column. To reduce the danger of voltage breakdown, the spaces between the central terminal and the upper and lower ends of the column are each subdivided by 150 equipotential plates, connected to the potential divider chains at the appropriate tapping points. The accelerator tube is housed inside the "stack" of equipotential plates and passes right through the ends of the pressure vessel. The tube is subdivided by conducting rings each connected to its corresponding equipotential plate, the aim being to limit the voltage across any one section of tube to 40 kV.

Negative ions are formed in a high-frequency gas discharge and are withdrawn from the discharge by preliminary accelerating electrodes, which are designed to produce a focused beam of circular cross section and fire this down the centre of the main accelerating tube. Electrons are stripped from the negative ions by passing them through an extremely thin foil inside the central terminal. On emerging at the lower end of the accelerator tube the beam is passed through a magnetic field adjusted to deflect the ions through a right angle and bring the beam to a focus on the particular target under investigation.

Operation of a high voltage electrostatic generator necessitates "pressurising" the vessel containing the accelerating electrodes. In this case the gas pressure is 250 lb. per sq. in., and the weight of gas in the main pressure vessel is approximately 2 tons. For maintenance purposes the gas must be removed and stored in suitable containers, and a considerable proportion of the cost of this type of installation is associated with the equipment for transferring the gas from reservoirs to the pressure vessel and keeping it dry and free from atmospheric contamination.

In the equipment described, the ions may move distances of about 120 ft. before reaching their target, and the target area must not exceed a few millimetres in diameter. It is thus necessary to maintain a very high vacuum throughout the entire ion path and also to control all the accelerating and deflecting fields to a high degree of accuracy. The accelerator tube is pumped at the top and bottom, and also via a by-pass tube at the centre, by 14 in. mercury diffusion pumps with large dry-ice traps and liquid-air traps in series. The accelerating, focusing, and deflecting fields are controlled by electronic stabilisers to an accuracy of a few parts in 100,000.

The higher energies available will permit the study of nuclear reactions produced by the bombardment of uranium and the transuranic elements, and a considerable advance in our knowledge of the nuclear properties of these elements is to be expected. By bombarding suitable light element targets with beams of protons and deuterons, it will be possible to produce neutrons of controllable energy in the range up to 30 MeV, and to study their interaction with other nuclei. This information is basic to the United Kingdom atomic energy programme, but is likely also to be of considerable fundamental interest. Other possibilities include the acceleration of heavier ions such as those of oxygen and fluorine. It will be seen that the tandem machine will considerably extend the range of studies that can be carried out with electrostatic generators.

Wisconsin Tandem Generator

A tandem Van de Graaff accelerator has been authorised for the University of Wisconsin by the United States Atomic Energy Commission. It will probably operate at a maximum of 12 MeV. Cyclotrons have operated in this range before but have not had the resolution, nor the flexibility, of the tandem machine.

Steel Economy in Proton-Synchrotron

The Governing Board of the National Institute for Research in Nuclear Science announce that a contract has now been signed for the supply of the magnet yoke, which is a major component of the 7 GeV proton-synchrotron being built for them on a site adjacent to the Atomic Energy Research Establishment at Harwell. The contract has been signed with Joseph Sankey and Sons, Limited, who have undertaken to supply the 340 steel blocks required, each weighing 20 tons, at a total cost of over £1,250,000. The special steel required will be supplied by the Steel Company of Wales. In his reply to a Parliamentary Question last July 30, the Prime Minister stated that work on the construction of this accelerator had been put in hand.

It is significant that the existing Soviet synchro-phasatron includes 36,000 tons of magnet steel, whereas the new British machine will require only 7,800 tons. The Soviet accelerator gives proton energies of 10 GeV as against the British 7 GeV, but the steel used is between four and five times as much. The reason for this discrepancy is that a principle known as strong-focusing is to be employed in the British machine. The same principle is to be used in a 50 GeV accelerator planned for the Soviet Union.

Progress at Berkeley

Work on Britain's first nuclear power station is proceeding rapidly. At Berkeley, on the River Severn, construction is already well advanced; a progress report on the station, which is being built by the A.E.I.—John Thompson group, appears below.

Civil Construction

Extremely heavy rainfall hindered the commencement of civil construction work on the Berkeley nuclear power station but now, nine

Civil-engineering work at Berkeley is already well advanced. Foundations for two reactors can be seen.

months after the start of the contract, the 30 ft. deep foundation for the pressure vessel of reactor No. 1 has been placed and the first lifts of concrete for the pad below reactor No. 2 have been completed. A report of the progress being made at the site is contained in *Team Spirit*, the house journal of John Laing and Son, one of the civil engineering contractors there. The following note has been taken from that report.

One of the early tasks was the excavation for and concreting of twin cable ducts, 72 in. in diameter, crossing the site. Since then the network of temporary ducts for service pipes has been constantly increasing. An 8 in. ring main from the company's compressor house encircles the site and from it 4 in. pipelines lead to the reactor foundations. Each of the two compressors supplies 750 cub. ft. of free air a minute at a pressure of 100 lb. per sq. in. In the deep excavations the water problem has been intensified by the nearness of the tidal River Severn but the two reactor pits have been kept dry by submersible pumps placed in 16 boreholes which ring each excavation and go 40 ft. below the lowest level of excavation. In constant use, they pump out thousands of gallons a week.

By the end of August excavation totalled 200,000 cub. yds.; 215,000 tons of hardcore had been imported and 30,000 cub. yd. of high-quality concrete and 2,400 cub. yd. of mass filling had been poured. The bulk of the concrete had been used in the foundations of reactor No. 1, on which operations in the past few months have been concentrated. The construction of reactor No. 2 is following a similar pattern and since work started on it, it has gone on simultaneously in the two excavations.

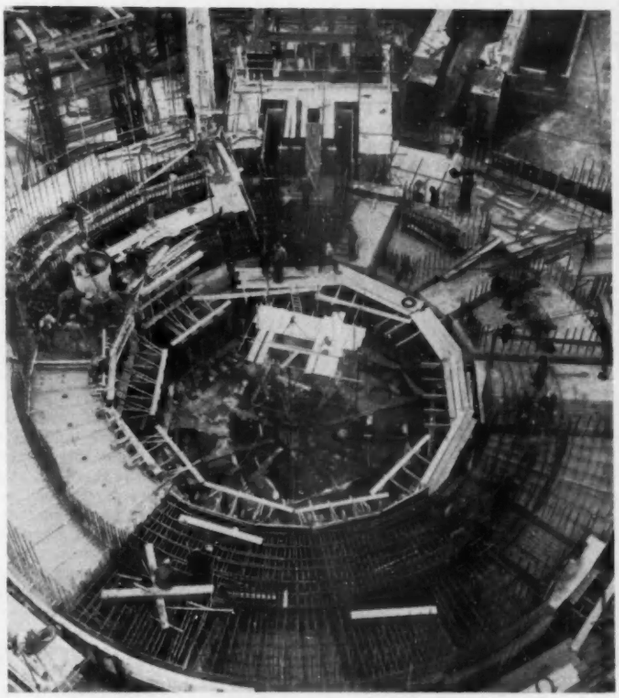
Each lift of concrete for the foundations of reactor No. 1 was divided into bays containing between 70 and 190 cub. yd. The first lift contained four layers of 1¼ in. square-grip steel. Subsequent lifts until the ninth were 3 ft. thick. The ninth lift immediately below the bottom dome of the pressure vessel was 4 ft. 6 in. thick. The concreting of the retaining walls and the foundations for the boilers, which will encircle the reactor, was carried out simultaneously.

The 240 ton bottom dome of the pressure vessel has been welded, supported on a cradle carried on four bogies. Rail track was laid from the pressure vessel building and a Bailey bridge placed from the perimeter to the centre of the foundations for the bogies to move it easily into position. As the pressure vessel is assembled *in situ* by John Thompson Limited, concreting will form a shell around it. This biological shield of high-density concrete will be 8 ft. 6 in. thick, poured in lifts 3 ft. deep.

Beside reactor No. 1 the first of the 15 ton monotower cranes, which will be used in constructing the reactor plant, has been completed and the second is nearing completion. Two similar monotower cranes are rising by reactor No. 2. Each crane is 130 ft. high, supported on a 15 ft. concrete base and lifts a maximum of 15 tons on a radius of 90 ft. Excavation will soon begin for a cruciform cooling pond to be situated between the two reactors.

The cornerstone of the progress in the concreting has been the Winget weighbatching plant which was brought into operation in May. Working to capacity the plant produces 700 cub. yd. of concrete a day. Five types of aggregate are brought by lorry and tipped into the ground-level storage bins, which together will hold 4,000 cub. yd., and are kept piled up by bulldozer. Bulk cement is unloaded into a ground feed hopper and lifted into four silos, each of which holds 125 tons, by means of air slides and bucket elevator.

From the weighing hoppers the materials are fed into two 2 cub. yd. mixers 14 ft. below. The concrete is discharged into two hoppers, one feeding trucks, the other discharging on to a wet-concrete reversible conveyor belt which feeds four pumps, each of which is driven by a 55 h.p. electric motor and can pour out 15 cub. yd. an hour through 6 in. pipes. The concrete is pumped to the working areas where it is compacted by pneumatic-poker vibrators. Eventually concrete will be pumped from ground level to a height of over 100 ft. Steam-heating plant is being installed alongside the weighbatching plant.



Concreting the first quadrant in lift nine for reactor No. 1. A 1,000 ton pressure vessel, part of which is shown below, will rest on this lift.

One of five similar 50 ft. diameter rings which form the cylindrical section of one Berkeley reactor pressure vessel. The plates are 3 in. thick.

Heat Exchangers and Reactor Vessels

John Thompson are responsible for the fabrication of heat exchangers and reactor vessels for the Berkeley station, and manufacture at the company's works at Wolverhampton is well in hand. The sixteen heat exchanger vessels are 18 ft. in diameter and are being made from mild steel 1½ in. thick. They are built up from cylindrical sections with domed ends at the top and bottom, the cylindrical sections being fitted with many inlet sleeves for connection to pipework and tube headers. Compensation rings, 5 ft. in diameter and 6 in. thick, are fitted to each domed section to make up the necessary strength at the connection to gas ducting from and to the reactor vessel. Each of the seven sections will be completed so far as is possible in the works before being transported to the site for assembly and welding into a complete exchanger, 70 ft. high. All the welding is, of course, to Class 1 requirements at Lloyd's, and the fabrication is therefore stress relieved after welding.

The cylindrical body sections of the vessels are each fabricated from two steel plates, roll-formed cold to shape in a large roll-bending machine in the bending and welding shop. This machine is capable of handling roll-formed shells up to 6 in. thick—such extra thick plates being first heated in an adjacent furnace.

The construction of reactor vessels for the gas-cooled stations is largely site work, using pressed petal plates from the boiler press shop for the domed-end sections and roll-formed plates for the cylindrical sections. The Berkeley reactor vessels are being made up of domed-shaped top and bottom sections and five bands of plates forming the cylindrical portion. The plate thickness is 3 in. and the vessel is 80 ft. high by 50 ft. in diameter.

A trial assembly of the reactor-vessel plates is being carried out before despatch to the site. In the case of the domed sections, this is done in a large 50 ft. diameter jig in the newly equipped fabrication shop. For the cylindrical sections, however, the rings of roll-formed plates are assembled on a circle of plinths, situated out of doors; one such ring, so assembled, is shown in an accompanying illustration.

General Notes

Windscale Shut-Down

No. 1 reactor at the Windscale plutonium plant has been closed down owing to an excessive rise in temperature of certain uranium fuel elements. It has been reported that cartridges had become red hot and were oxidising; temperatures were said to have risen from the normal 390 deg. C. to 500 or 600 deg. C. Cold water has been used for cooling the affected areas, and it was stated that the local hazard was negligible. However, more recent reports state that milk samples in the area have been found to have a radioactive iodine content six times the permissible level.

No official explanation was given by the beginning of this week, but presumably a restriction in the coolant channels has prevented adequate heat removal by the cooling air. The

significance of the mishap is twofold. As yet no atomic power station has operated over a long period and it remains to be seen whether they can do so without serious breakdowns. Growth of graphite moderator and fuel-element distortion may still be serious problems, though great improvements in monitoring, moderator design and fuel charging and discharging have been introduced since the Windscale plant was built. Air supports combustion; carbon dioxide does not. The second consideration is one of safety. The reactors at Windscale are air cooled and heat goes up the chimney, carried by the gas. At Calder Hall and in all power stations the heat is used for power production; the coolant gas is contained in a closed circuit and any radioactive products picked up by the coolant cannot escape to atmosphere. (Comment in Plain Words.)

International Agency

The general conference of the International Atomic Energy Agency has approved the appointment of Mr. Sterling Cole of the United States as director general of the Agency. The election was unanimous.

Graphite Moderator Patents

A number of factors influence the design of graphite moderators, one of the most important being the phenomenon of growth under irradiation (generally referred to as Wigner growth), which is affected by the quality of graphite, the direction of grain, neutron bombardment and temperature. These factors led to careful consideration of the design of individual blocks. The production of the graphite itself has been the subject of intensive study, and quality varies between the outer perimeter and the centre. Two United Kingdom Atomic Energy Authority patents already published and one to be published on November 6 are concerned with these problems. They are No. 784291 and No. 784,292 (both already available) and No. 785,876. The patents are illustrated with drawings showing graphite configuration.

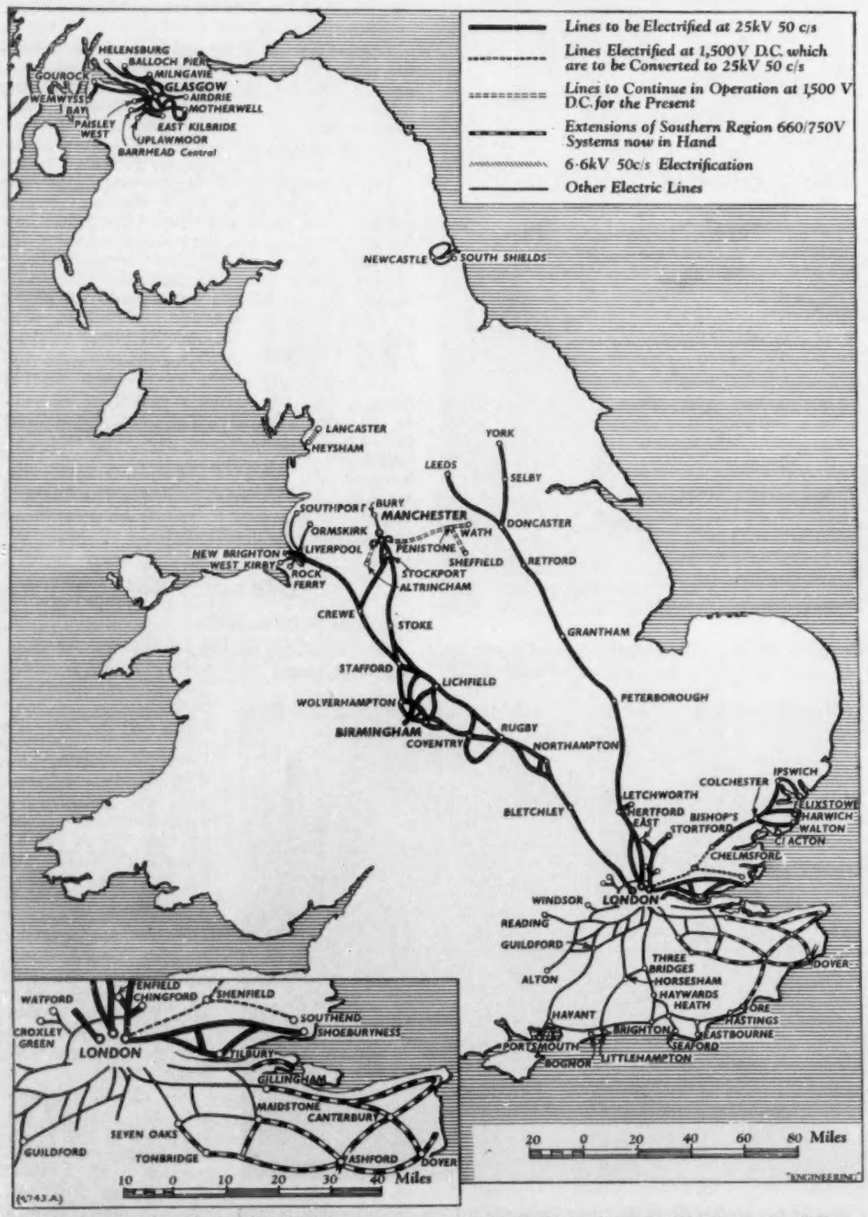
ConFusion

In our report of the Physical Society's conference on plasma and atomic physics last week, certain errors arose. Although the description of the apparatus for fusion work at Aldermaston was substantially correct, there was some confusion in our account of the experiments. The authors concerned have kindly provided a typescript of their paper, which will be published in detail in a subsequent Atomic Review.

Construction

RAILWAY MODERNISATION—DUAL VOLTAGES RETARD PROGRESS

Continued from page 453, October 11



The implementation of the electrification scheme for British Railways is made difficult by the different operational voltages existing throughout the country. The map shows the various schemes under development.

ELECTRIFICATION

The decision taken by the British Transport Commission in 1956 to adopt the high-voltage single-phase system of alternating current traction at 25 kV (or 6·6 kV where clearances are restricted) was so momentous that it is easy to regard the present electrification schemes as having originated at that time. In actual fact they were all proposed in the modernisation plan a year earlier, at which time it was generally supposed that those outside the Southern Region would be carried out on the 1,500 volt direct current system recommended in the Cock committee report of 1951. The vast amount of development work made necessary by the adoption of the a.c. system may have retarded realisation of the long-distance main line schemes but it is considered that most of the programme should be completed well within the 15-year period of the plan. This will bring the possibility of undertaking further projects in the late 1960s, and consideration is now being given to such work.

In the following table those parts of the a.c. schemes on which work is in progress are listed with their present estimated dates for completion :—

	Date forecast for completion
Manchester–Crewe[1]	1959
Colchester–Clacton–Walton[2]	1958
Liverpool Street–Chelmsford–Southend[3]	1959
Liverpool Street–Chingford–Enfield and Bishops Stortford	1960
Fenchurch Street–Tilbury–Southend	1961
Glasgow suburban	1960-61[4] (North of Clyde) 1962 (South of Clyde)

NOTES:
[1] Pilot scheme for Euston–Birmingham–Crewe–Manchester–Liverpool electrification.
[2] Pilot scheme for main-line electrification to Ipswich and proving ground for rolling stock to be used in London suburban schemes at 50 cycles per sec.
[3] Conversions from 1,500 volt d.c. system now in use.
[4] First phase, comprising 71 route-miles.

Tentative dates for the completion of the other schemes are: Chelmsford to Ipswich, including the Harwich branch, 1965; Kings Cross and Moorgate to Hitchin and Letchworth, including the Hertford loop, 1962; and Hitchin to Doncaster, Leeds, and York, 1970.

The first contracts for 50 cycles per sec. electrification equipment were awarded in

October, 1956, and covered the overhead system for the Crewe-Manchester and Colchester-Clacton-Walton pilot schemes. Several years' experience of 50 c/s traction had already been gained in this country on the Lancaster-Morecambe-Heysham lines in the London Midland Region, where trial running began in 1952 on the strength of the suggestion in the Cock report that the system should be studied for possible application on secondary lines with light traffic. Various forms of overhead construction had been installed experimentally on this section, and one manufacturer had established a special research centre for investigating problems connected with overhead conductors, catenaries and supporting structures for high-voltage a.c.

Beginning with an adaptation of industrial multi-anode rectifier equipment, the Lancaster-Morecambe-Heysham trains were fitted later with single-anode rectifiers, transformers and control gear suitable for underframe mounting (the original equipments were accommodated inside the motor coaches). An important development was the appearance at the end of 1955 of a germanium rectifier for traction, the first of its kind in the world. This unit has undergone extensive trial running in one of the motor coaches.

Last January the first contracts for 50 c/s traction equipment for the lines to be electrified under the modernisation plan were announced. They were for multiple-unit stock, and constituted the largest order for vehicles of this type for 50 c/s operation which had been placed up to that time. In accordance with the policy adopted when the 50 c/s system was chosen for British Railways, all the motor coaches are to be equipped with rectifiers and d.c. motors. The 35 germanium equipments to be supplied for the Manchester-Crewe stock form the largest order yet placed in any country for germanium traction rectifiers. In the table below the numbers of units involved and the areas in which they will operate are shown:—

Glasgow suburban ..	91 three-car sets
Manchester-Crewe ..	35 four-car sets
Fenchurch Street-Tilbury-Southend ..	112 four-car sets
Liverpool Street-Enfield-Chingford-Bishop's Stortford	70 three-car sets

All the above rolling stock will be built in British Railways workshops and equipped by contractors. It is expected that the first of the Fenchurch Street-Southend sets will go into service initially on the Liverpool Street-Chelmsford-Southend routes in order to release the existing 1,500 volt d.c. stock for conversion to the a.c. system. These sets, when converted, will return to their present lines enabling the Southend *via* Tilbury trains to take up their duties on that section.

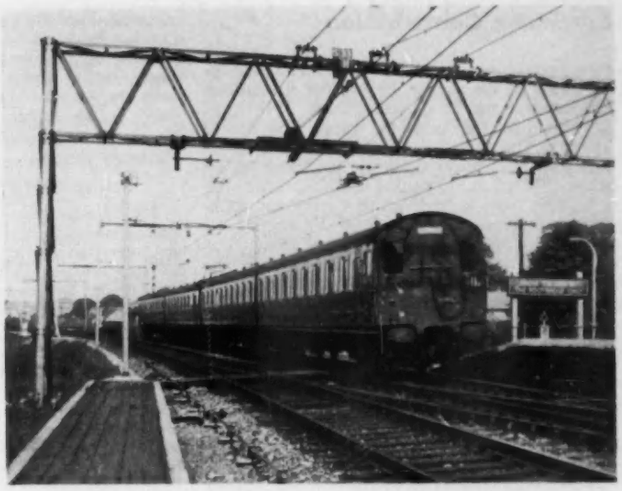
Fifty circuit-breaker equipments for lineside installation on the Manchester-Crewe and Colchester-Clacton sections were ordered at the same time as the traction equipments for rolling stock.

It may be recalled that a 1,500 volt d.c. overhead system was erected between Stratford and Fenchurch Street at the time of the Liverpool Street-Shenfield electrification of 1949, but the proposed Fenchurch Street-Stratford shuttle service did not materialise. The overhead line remains, however, and is energised at 6·6 kV from time to time for rolling stock trials and other a.c. electrification tests.

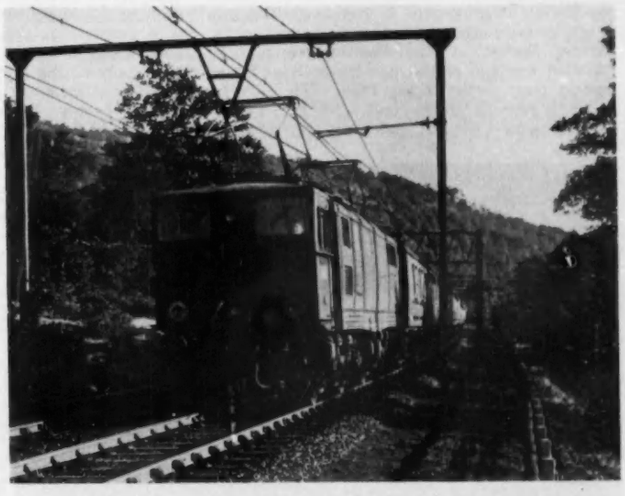
The multiple-unit equipment orders were followed in March by the first contracts for a.c. locomotives, covering 60 to be built by contractors, and 40 sets of electrical equipment for locomotives to be built in British Railways workshops. All conform to a single basic specification for a Bo-Bo rectifier locomotive with a continuous rating of 3,300 h.p. and a top speed of 100 m.p.h. (Type A) or 80 m.p.h. (Type B) according to gear ratio. Type A locomotives will haul express passenger trains at speeds up to their maximum, or mineral trains of up to 950 tons at 55 m.p.h. Type B will be capable of hauling mineral trains of up to 1,250 tons at 55 m.p.h. In all locomotives the motors will be fully springborne in the bogies and will be geared to the axles through flexible drives.

Signalling and telecommunications circuits require special treatment on a 50 c/s system to avoid interference from traction current or from rectifier harmonics. Equipment has been ordered for modifying the existing a.c. track circuits on the Liverpool Street-Chelmsford-Southend lines and for track-circuiting in the Colchester-Clacton-Walton and Manchester-Crewe areas. Where single-rail d.c. track circuits can be used, the a.c. traction system causes little complication beyond the need for protecting d.c. signalling apparatus against stray a.c. by means of chokes and filters. In some areas, however, double-rail track-circuiting is necessary and here the signalling currents must be differentiated by frequency from the traction supply, since both flow in the same rails. Systems to be installed so far involve either the central generation of a special-frequency supply for signalling, or frequency-converting equipment operating in each track circuit in conjunction with a discriminator and a rectifier for feeding a d.c. relay.

The proposals for a.c. electrification excluded the 660 volt d.c. system of the Southern Region. A major event in that Region during recent years has been the change-of-frequency scheme in the London area, which has involved the replacement of



The present d.c. rolling stock on the Southend line, shown above, is to be replaced by four-car sets operating at 25 kV a.c.



The Marylebone-Manchester express on the Manchester-Sheffield 1·5 kV d.c. electrification scheme—the first all-electric main line in Great Britain. All the locomotives have been equipped by the Metropolitan-Vickers Electrical Company, Limited.

A Euston-Watford train composed of two of the new three-car sets equipped by the General Electric Company, Limited, this year for the L.M.R. London suburban 630 v. d.c. line.

Continuing Construction

rotary-converter substations, fed from a specially-generated 25 c/s supply, by rectifier substations connected to the 50 c/s grid system. Provision has been made for raising the voltage from 660 to 750 volts, and the latter voltage will be used in the East Kent electrification scheme now being undertaken. This is in two phases, the first covering the main lines from Gillingham to Faversham, Margate and Ramsgate; and from Faversham to Canterbury and Dover. The second phase comprises the principal boat train route from Sevenoaks through Tonbridge to Ashford, Folkestone and Dover, with the connections from Ashford to the Sussex coast electrification at Ore; to Canterbury, Minster and Ramsgate; from Minster to Buckland Junction (Dover); and from Paddock Wood to Maidstone. Orders for rectifiers, switchgear and remote supervisory control apparatus covering both phases were placed in May. Electric working will be introduced in stages between 1959 and 1962.

Much of the traffic in the Kent Coast electrification will be worked by multiple-unit sets, but thirteen 2,500 h.p. electric locomotives are being built for boat trains and other services which do not lend themselves to set formations. The locomotives will incorporate a motor-generator control system with flywheels to maintain a supply to the traction motors while negotiating lengthy gaps in the conductor rail. A similar system is used in the three units on the Central Section of the Region, which have included haulage of the Newhaven boat trains among their duties since 1949. The Region will also provide ninety-eight 1,500 h.p. Diesel-electric locomotives for goods services, but this traffic will be shared by the electric locomotives, which, like their Central Section predecessors, will be equipped with pantographs for collecting an overhead supply in yards and other areas where a third rail would be inconvenient.

Various improvements in electric services and rolling stock which have been effected since the modernisation plan was announced had their origin in the preceding years. In 1955 fifteen new two-car suburban sets comprising both centre-corridor and compartment accommodation were introduced on the South Tyneside line of the North Eastern Region. These vehicles are similar to recent suburban stock on the Southern Region and to the 57 three-car sets with which in May this year the London Midland Region began the replacement of older trains on the Euston to Watford and Broad Street to Richmond services. With the summer timetable of 1956 the Liverpool Street-Shenfield electrification was extended to Chelmsford and new four-car main-line sets were put into traffic on the London-Brighton and London-Littlehampton services of the Southern Region. The most recent major addition to electric services has been the Shenfield-Southend extension, inaugurated on December 31 last, and accompanied by important accelerations and increases in frequency of trains.

DUAL VOLTAGES NECESSARY

The first British all-electric main line scheme was completed in January, 1955, when, with electrification of the three miles from Sheffield to Rotherwood Sidings, the Manchester-Sheffield-Wath undertaking reached finality. No good purpose is served by under-estimating the problems to be overcome before electric traction replaces other motive power for all traffic on another main line in this country. Already it appears that some of the estimates of saving in costs by adopting a 50 c/s system were over-optimistic.

The present British Railways plan is distinguished from similar undertakings on the Continent by the necessity of using two voltages —a legacy from the restricted clearances of early days which also had some effect on steam locomotive development by precluding the use of large low-pressure cylinders in compound designs. This involves equipping all locomotives and motor coaches with means for automatic adjustment of the electrical connections while passing at speed from one voltage to the other, with precautions against temporary low-voltage conditions on the contact line causing incorrect setting-up of the circuits. When it is remembered that locomotives and motor coaches are also to become mobile rectifier substations, it will be seen that there has been a drastic departure from the relative simplicity of d.c. traction. It is often pointed out, and has been shown in practice on the Continent, that a light four-axle rectifier locomotive will give the same starting performance as a six-axle d.c. locomotive with conventional series/parallel control, but it is doubtful how far the cheaper mechanical construction will counterbalance the cost of the more complex electrical equipment, particularly in the British Railways case.

It has not yet been made clear how numerous or extensive the low-voltage (6·6 kV) areas will be. It has been suggested that the standard of overhead construction used in these areas will govern the whole scheme, for the pantograph pressures necessary for satisfactory collection at speed in these zones might be too high to allow the use on the 25 kV sections of an overhead system as light as that which has been general in high-voltage 50 c/s electrification on the Continent.

The adoption of the rectifier system for British Railways locomotives and motor coaches has given a valuable impetus to rectifier development in this country. Of particular interest is the adoption of semi-conductor (germanium) power rectifiers in 35 motor coaches and their possible use in some of the locomotives. The mercury-arc rectifier has similarly undergone improvements in power/weight ratio and a reduction in size which are revolutionary compared with the designs available when the first Lancaster-Morecambe-Heysham motor coaches were equipped five years ago.

GENERAL

In connection with the contracts so far placed for electric rolling stock, certain equipment not hitherto required in British practice has been ordered from the Continent. This applies to high-speed circuit-breakers for rolling stock and to flexible drives for locomotives to allow the use of fully-springborne motors instead of the axle-hung arrangement which has been universal in this country hitherto. It is also likely that a Continental design of lightweight pantograph will be used in the first motor coach and locomotive installations for British Railways' use.

Civil engineering work is in progress on the Manchester-Crewe, Colchester-Clacton, London suburban, and Glasgow areas and overhead equipment has been ordered for the first phase of the Glasgow scheme. On the London, Tilbury and Southend section, a major undertaking is in hand at Barking to separate conflicting routes by means of two flyovers and a flyunder, so that more frequent services may be run after electrification and long-standing sources of delay removed as far as possible. Elsewhere the work at present consists mainly of lowering track or reconstructing bridges to provide clearance for the overhead line. An interesting design of 8½ ton Diesel-electric travelling crane is being introduced on the Eastern Region for work on heavily-occupied lines where interference with normal traffic must be minimised. The cranes will be able to work singly or in tandem on one line without blocking the adjacent track.

Careful avoidance of inductive effects in telecommunications circuits is another problem associated with electrification at 50 c/s. Specially-screened cables have been ordered in which effective earthing and protection of the screen against corrosion benefit from recently-developed techniques.

The 50 c/s programme makes wider demands on general electrical engineering technology than any other form of railway electrification hitherto undertaken in this country.

More 750 v. d.c. locomotives are being built for the East Kent electrification in the Southern Region. One of the original three of the type, equipped by the English Electric Company, Limited, is seen leaving Victoria with the Newhaven boat train.

Work is in progress on the flyover to carry St. Pancras-Tilbury lines over the London Transport and Fenchurch Street-Southend lines. The flyover will run on the line of concrete beams seen on the left to connect on the far side with the pier seen in the right background.

STRUCTURAL ENGINEERING AND RESEARCH

Presidential Address to the Institution of Structural Engineers

During the Twentieth Century, structural engineering has been characterised by the increasing use of mathematics. Throughout the period, structural engineers have benefited from a vast amount of research work, some of which has been undertaken by the universities and some by themselves in the course of their professional duties. The history of this research was traced by Sir Alfred Pugsley, O.B.E., F.R.S., when he delivered the inaugural address of the new session to the Institution of Structural Engineers on his being inducted as President on October 3.

As being among the earliest example of an engineer turning to research workers for assistance, he quoted Telford's approach to the then President of the Royal Society, David Gilbert, for a theoretical treatment of the catenary. This inquiry gave rise to the theory of "a cable of uniform strength" in its well-known form, published in the year 1826, which was the same date as the opening of the Menai Suspension Bridge in respect of which the inquiry had been made.

The real significance of experiment, suggested Sir Alfred, was the need to convince designers generally of the correctness of research results. Much of this work was done in the universities and a good example of experiments were those of Professor Andrew Robertson on the strength of steel columns. This work was done at Bristol University between the wars; carried out in conjunction with the Steel Research Committee, the study had ultimately resulted in the Perry-Robertson formula that has enjoyed so much popularity with designers ever since.

The advent of new materials had given rise to many advances in the field of structural engineering. The whole of structural theory had grown with the introduction of cast iron and the need for a theory of bending. Similarly, the theory of frames could be said to have originated with the use of wrought iron bars as tension members in trusses. New materials had also caused work to be done that might well have been undertaken earlier in respect of the older conventional materials. In particular, the use of aluminium alloys in shipbuilding has been accompanied by some interesting researches into the buckling of plating and into the diffusion by shear of bending stresses in a ship's hull into its superstructure. But the actual results, though obtained to make possible the introduction of aluminium alloy, should have been known earlier for the better design of steel ships. The results were almost equally applicable whatever the material.

Not all the work has been undertaken at the universities, however, and Sir Alfred instanced the experiments of Dr. Oscar Faber, as the work of a consulting engineer who had made a great contribution to the development of codes of practice. In particular, he discussed Faber's work on the behaviour of reinforced columns which had led to the revision, in a fundamental sense, of our notions of the ultimate strength of reinforced concrete columns under long-continued loads in a building. A few selected experiments, backed by a clear physical understanding of the problem and expressed by simple theory, had indeed been powerful in the hands of an experienced designer.

The existence to-day of very many well-equipped material and structural laboratories made it difficult to realise that the first commercial testing house, built by Kirkcaldy in 1866, remained a lonely example for many years and was not followed by university laboratories until those of Kennedy at University College of London in 1878, Unwin at Cooper's Hill in 1883, and Hele Shaw at Bristol, also in 1883. Their equipment had been extremely limited for many years, in each case consisting principally of one testing machine only. It had been the two wars of this century that had been largely responsible for giving structural testing a new impetus and range, so that it was now a settled and growing habit of research workers and designers alike.

WATER SUPPLY IN SOUTH ESSEX

Hanningfield Reservoir and Treatment Works Commissioned

The last substantial water supply available to southern Essex has now been exploited by the completion of the Hanningfield reservoir and waterworks. That is to say, any future growth in demand for water by either industry or domestic users in the area will give rise to a supply problem apparently answerable only in terms that hitherto have been regarded as utterly uneconomic: treating seawater or water drawn from the Thames and other rivers at points below discharges from sewage works.

The Hanningfield scheme is a joint venture promoted by the Southend Waterworks Company and the South-Essex Waterworks Company. It comprises intake works from the rivers Blackwater and Chelmer at Langford; a 48 in. pipeline which then carries the water 9 miles to the newly constructed reservoir at Hanningfield; treatment works; and connections into the two companies' distribution systems. When fully operative, these works will yield about 21½ million gallons a day, to be divided equally between the two supply areas. The reservoir has a capacity of just under 6,000 million gallons.

No difficulty was presented in securing a watertight reservoir, for Hanningfield is located on the London clay. The site is, however, on relatively high ground (high-water level is at 181 ft. above sea level) and the principal embankment which had to be constructed is 6,850 ft. long, with the cut-off trench nearly 100 ft. longer than that. The average height of the embankment is some 64 ft. and it was considered too great a risk to attempt to build such a high embankment in clay in the three years which could be allowed for construction. A conventional cross-section was therefore adopted, using a clay-puddle core with a sand casing and gravel fill for the body of the embankment. This gravel fill was obtained from neighbouring pits, the average haul being about 8 miles by road. The crest width of the embankment is 25 ft. which has provided for a 9 ft. wide access road along the whole length. On the flank of the embankment a 62 ft. beam has allowed the construction of a 20 ft. roadway to replace a country lane which has been submerged.

At the far end of the reservoir, which is very roughly a truncated triangle in plan, a second dam has been built separating the main water from a second reservoir that receives the drainage from the immediate catchment area. This second embankment, much shorter and shallower than the main dam, has been built of clay throughout and the opportunity has been taken to insert pore-pressure gauges that will provide fundamental data about the development of strength of such clay embankments. This study is in the hands of Soil Mechanics Limited and may well make the construction of these banks a safe proposition to the height of 50 or 60 ft.

The 48 in. aqueduct bringing the water enters the reservoir at the north-east corner, adjacent to the eastern extremity of the main dam. This point is also close to the site which had to be chosen for the treatment works but to promote circulation in the reservoir—and so as not to take only newly treated water, leaving much of the reservoir stagnant—the intake tower is located on the far side. From the intake tower the water is conveyed in a 48 in. aqueduct laid on the bed of the reservoir to the valve tower which has been built at about the mid-length of the dam. Shallow water has been avoided by excavation and by giving the perimeter a 1 in 3 batter, protected by pre-cast concrete slabs. Water circulation is also enhanced by additional subsidiary intakes—one from the "local" reservoir and two more from the adjacent sludge lagoons. Draw-off is also possible at the valve tower.

At the treatment works, softening and sedimentation of the water is effected by four "accelerators" of the upward-flow sludge-blanket type. Softening is carried out mainly by the addition of lime and alumina, a well-equipped chemical house having been built to store and handle the additives. The degree of softening required is dictated by the traditional supply of the Southend Company who, originally drawing their water from some chalk beds, were able to provide, without any cost of treatment, a very soft water. After softening, the water passes to a contact tank, the excess alkalinity of the water being removed by the injection of carbon dioxide produced by the combustion of coke. The extensive plant necessary to make the CO_2 is housed in a separate building, waste heat being used to warm the chemical house and the filter house.

After passing the contact tank the water is delivered to eight rapid-gravity filters. Each filter is washed by first loosening the sand with compressed air and then by subjecting it to an upward wash of water. Beyond the filters the water is chlorinated and passes to two covered contact reservoirs of a total capacity of 2 million gallons and thence to a further pumping station.

This pumping station delivers the water as required into the pipelines of the two companies. Three electrically driven centrifugal pumps have been installed for each company, though of different sizes for the pumping distance and head are both larger in the case of the Southend company. Electricity is at present taken from the grid, but it is proposed to instal two Diesel-alternator sets, each of 500 kW. The station itself is a reinforced-concrete frame with brick infilling; rather surprisingly, it was learnt that the frame members were cast in situ rather than being pre-cast on the floor and then slung into position.

The cost of the scheme—which also includes an office block and a small housing estate—has so far exceeded £5 million. Two firms of consulting civil engineers have supervised the work: Messrs. Binnie, Deacon and Gourley, and Messrs. T. and C. Hawksley; the electrical consultants were Messrs. Heap and Digby. The principal civil engineering contractors were W. and C. French Limited; equipment for the treatment works was supplied by the Paterson Engineering Company, Limited.

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TRANSISTOR FACTORY

The construction of a factory for the production of transistors has been announced by Semiconductors Limited, Vicarage-lane, Ilford, Essex. It will be located on the Cheney Manor Estate, Swindon. Air-conditioning equipment will regulate temperature, humidity, and dust concentration in the main production areas to ensure that the manufactured transistors are free from unwanted impurity. Production is to start in 1958 with transistors that give useful amplifier service up to 40 Mc/s and switching rates of 20 Mc/s.

Continuing **Construction**

52-YEAR-OLD SUBSTATION REPLACED

It was in 1905 that the original substation at Charing Cross was opened to supply electricity to the District Railway. Until this year, the original four 1,500 kW rotary converters, supplemented in 1914 and 1921 by two more, have continued to supply power, not only to the District Line but also to the Northern and Bakerloo lines. Now a new substation has been constructed which employs mercury arc rectifiers instead of rotary machines, and the originals are to be given well-earned retirement. The last of the sets installed broke down soon after the order for the new equipment had been placed. Two 1,000 kW portable units were installed to avoid the cost of repairs.

The old station would not be counted as good planning nowadays. It is wholly below ground, and seepage water in the sump and cable ducts rises and falls with the tide. The only accesses for plant is through a door from the District Line platform, and once inside there is not sufficient head room for the crane to operate until clear of the gallery. At first, ventilation was virtually non-existent—a 2 ft. hole in the wall opening on to the railway sufficed. Moreover, the later sets had to be mounted at a higher level to clear the top of the Northern Line tunnel. It had, however, one advantage—it was never cold.

In contrast, the new station is wholly above ground. The exterior has been designed to match the surroundings and great attention has been paid to adequate ventilation. Being built over the District Line, a considerable amount of foundation work was required, including a new 65 ft. girder to span the tracks and platforms. However, since static plant is employed, the work was not as massive as it might have been, and the installation has been made on suspended floors. The design was prepared by Mr. T. Bilbow, architect to London Transport, and lightweight construction has been used as far as possible. In particular this has been applied to the roof in the rectifier section, which is made of lattice beams carrying aluminium ventilation and decking. Hammond and Miles Limited were the main contractors.

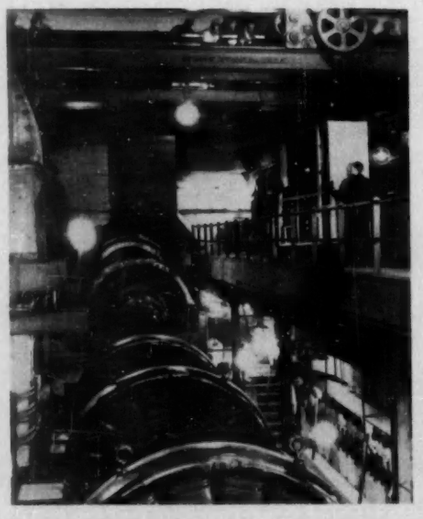


Fig. 2 A breakdown of the end set, after the contract for the new substation was settled, was remedied by the installation of temporary rectifier equipment.

Whereas the old station was fed from Lotts Road power station at 16⅔ cycles, the new equipment is being supplied from Greenwich (via Aldgate switch house) at 50 cycles. The final capacity will be eight 1,500 kW rectifier sets, of which only six will be installed in the first instance. Each set all are made by the Hackbridge and Hewittic Electric Company, Limited, Hersham, Surrey, consists of a pair of 750 kW half-units, each with its own transformer and each employing 6 phase rectification. It is arranged, however, for the combined set to operate 12 phase, by winding one transformer with a star primary, the other being connected in delta, so that the secondary phases of one are 30 deg. out of phase with those of the other.

As at the Bond Street substation, the transformers are closed-circuit air-blast cooled, thus eliminating the risk of fire. Each one is housed in a sheet steel enclosure, the air in which is continuously circulated through a heat exchanger in the form of a tubular radiator with an external cooling fan. By this means the heat developed in the transformer is dissipated indirectly and no dust or dirt is thereby drawn into its windings.

The rectifier bulbs are mounted above the transformer housings. The interphase transformers, fan control reactors and auxiliary transformers are located between the pair of main transformers forming a 12 phase set. It would have been impossible to get the required plant capacity into the space available, without using this type of construction—a 1,500 kW set covering a floor area only 9 ft. square.

Linking facilities are provided so that one of a pair of half-units can be isolated, while attention is given to circulating fans or any other item, and the remaining half continues to give its 750 kW output, the rectification then being temporarily 6 phase. Removable gantries can be readily fitted to the cubicle framework for access to the bulbs and starter units.

The high tension switchgear (by Switchgear and Cowans Limited, Manchester) comprises a bank of 14 vertical isolation units rated at 11,000 volts. The board is divided into three sections by bus couplers. Earth leakage and Translay protection are included. The 630 volt direct-current switchgear is by Bertram Thomas (Engineers) Limited, Manchester, and is mounted in two banks facing each other. One bank controls the positive and the other the negative lines. The banks are divided into three by couplers, section 1 feeding two northbound and two southbound sections of the Northern Line (including lifts and escalators). Section 2 feeds four similar lengths on the Bakerloo, and section 3 the District Inner Circle Lines. A test panel on one wall allows the truck switches to be checked away from the panel. In addition, there is the switchgear for station lighting and auxiliaries and for signalling equipment. The last will be retained at 33⅓ cycles to prevent interference from the 50 cycle supplies. Cables were supplied by W. T. Glover and Company, Limited, Trafford Park, Manchester, 17.

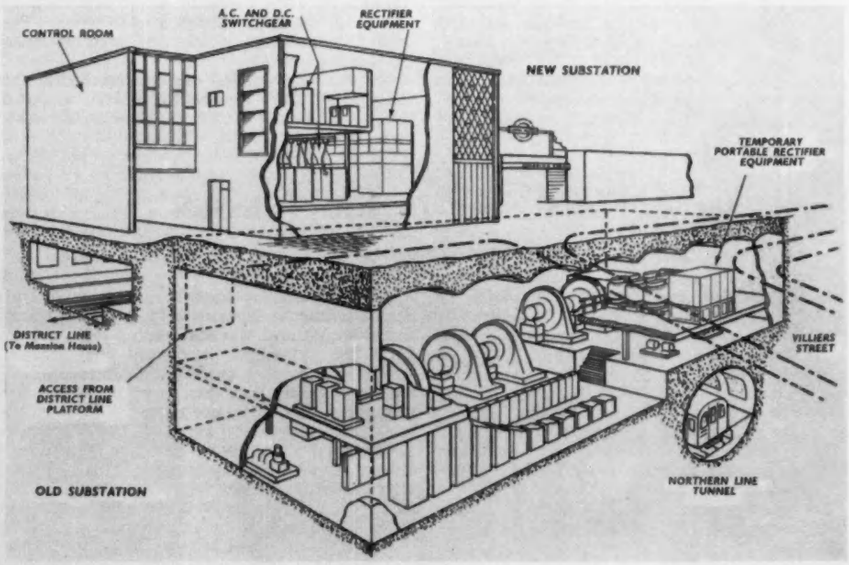


Fig. 1 (above) The new and the old substations at Charing Cross afford an interesting contrast in styles.

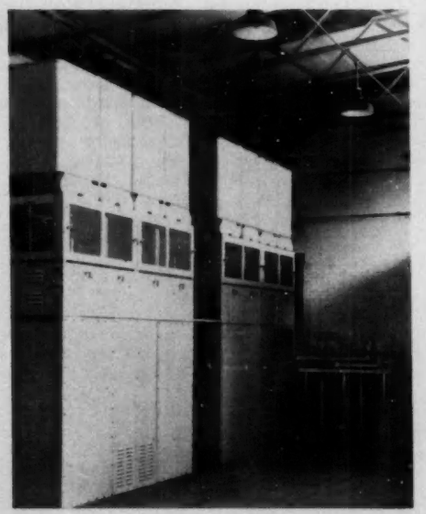


Fig. 3 Six 1,500 kW mercury rectifiers, with closed circuit cooling, form the new equipment.

All the new equipment is temporarily remote-controlled from the old substation by a centralised control panel. In the near future permanent control panels will be installed in a control room, on the upper floor of the new building. These panels will also provide remote control for the rotary converter substation at Lambeth, which has hitherto been controlled from the old Charing Cross substation. Space is available for similar equipment for the remote control of four or five other substations.

It is expected that the last of the traction feeds will be connected to the new substation early in the New Year (the work depends on " possession" of the track), but completion of the connection of the auxiliary supplies will not be possible before next spring.

Continuing **Construction**

AUTOSTRADA OF THE SUN

The Minister of Transport's promise of a road to the Channel ports is welcome news. It is a very minor project, however, compared with developments now taking place in the Common Market countries, notably Italy. The north of Italy already has a network of motor roads giving fast communication to the French and Swiss frontiers. The Centre and South are not so well served. When it comes to road-making, a peninsula is not a bad shape for a country.

Italy has now embarked on the construction of a backbone highway 450 miles long from Milan to Naples. This new super-road, called the "Autostrada of the Sun" will follow the line Parma-Bologna-Florence-Rome-Naples. The whole project will take nine years and cost about £110 million. The interesting thing to British readers, accustomed to being told that we cannot afford new roads, is that the Italian Government only pays 36 per cent. of the cost. The other £70 million is provided by the concessionaires who will recoup themselves by charging tolls for the use of the Autostrada. The road reverts to the State without payment after 30 years. The firms setting up the construction company include Fiat, Pirelli, Italcementi and Agip.

NOTICES OF MEETINGS

Building Centre

LONDON
Film Display: "Building with Straw," exhibited by Stramit Boards Ltd. Wed., Oct. 23, 12.45 p.m.

Chemical Society

ABERDEEN
"Anti-Knock Action of Tetraethyl-Lead," by Professor A. D. Walsh. Aberdeen Branch. Marischal College, Aberdeen. Fri., Oct. 25, 7.30 p.m.
DURHAM
"Chemical Engineering in the Atomic Energy Industry," by Professor P. V. Danckwerts. Newcastle and Durham Branch. West Building, Science Laboratories, The University, Durham. Mon., Oct. 21, 5.15 p.m.
EDINBURGH
"Acetylene-Allene Chemistry," by Professor E. R. H. Jones. Edinburgh Branch. 24 George-street, Edinburgh. Thurs., Oct. 24, 7.30 p.m.
PORTSMOUTH
"Photography in Scientific Investigation," by Dr. R. H. Hertz. Southampton Branch. College of Technology, Portsmouth. Tues., Oct. 22, 7 p.m.

Engineering Metrology Association

LONDON
"Precision Length Measurement in Australia," by P. Holmes. Thurs., Oct. 24, 7 p.m.

Illuminating Engineering Society

BIRMINGHAM
"Horticultural Lighting," by A. W. Gray. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Oct. 25, 6 p.m.
BRISTOL
"Lighting as an Effective Aid to Architecture," by H. E. Bellchambers. Bath and Bristol Centre. Royal Hotel, Bristol. Mon., Oct. 21, 7 p.m.
GLOUCESTER
Discussion on "Home Lighting." Gloucester and Cheltenham Centre. Fleece Hotel, Westgate-street, Gloucester. Tues., Oct. 22, 6.30 p.m.

Incorporated Plant Engineers

LONDON
"Complexity of Plant and the Training of Operatives," by N. D. Pirrie. London Branch. College of Preceptors, Bloomsbury-square, W.C.1. Thurs., Oct. 24, 7 p.m.*
CARDIFF
Discussion on "Lubrication" (with films). South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 22, 7.15 p.m.

Institute of Marine Engineers

BRISTOL
"Elimination of Torsional Vibration in Diesel-Engine Transmission Systems by Flexible Coupling Incorporating Forced Viscous Damping, also Considered in Conjunction with Engine Isolation," by G. Hallewell. West of England Section. Grand Hotel, Bristol. Mon., Oct. 21, 7.30 p.m.
CARDIFF
"Welding Metals by Pressure," by Professor A. R. E. Singer. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Oct. 24, 7 p.m.
GLASGOW
"Survey of Ships," by R. E. Knowles. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Oct. 23, 7.30 p.m.

Institute of Packaging

SHEFFIELD
"Frozen Food Packaging," by M. J. Smedley. Sheffield Branch. Grand Hotel, Sheffield. Mon., Oct. 21, 7.30 p.m.

Institute of Physics

BIRMINGHAM
"The Physicist in the Atomic Energy Authority (Industrial Group)," by L. Rotherham. Midland Branch. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham 2. Tues., Oct. 22, 7 p.m.

Institute of Road Transport Engineers

EDINBURGH
"Various Trends in Machining and Inspection Methods Concerning the Manufacture of Heavy Commercial Vehicles," by R. P. Chilton. Scottish Centre. North British Hotel, Edinburgh. Mon., Oct. 21, 7.30 p.m.

Institution of Civil Engineers

LONDON
"Water Supply from the Yeovil District (Sutton Bingham Scheme)," By R. C. S. Walters and R. J. C. Walton. Tues., Oct. 22, 5.30 p.m.*
Graduates' and Students' Conversazione. Fri., Oct. 25, 7.30 to 11.30 p.m.
LIVERPOOL
"Construction of a Modern Oil Refinery," by P. G. Hall. North Western Association. Liverpool Engineering Society. 9 The Temple, 24 Dale-street, Liverpool. Wed., Oct. 23, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"The Measurement of High Voltages with Indicating or Recording Instruments," by G. W. Bowdler. Measurement and Control Section. Tues., Oct. 22, 5.30 p.m.*
Chairman's Address: "Too Much and Too Little," by Professor M. G. Say. Supply Section. Wed., Oct. 23, 5.30 p.m.*
"The Post-War Electrification of the Polish State Railways," by J. Podoski. Utilization Section. Thurs., Oct. 24, 5.30 p.m.*
BIRMINGHAM
Discussion on "Co-ordination of the Initial Courses for Engineering Students," opened by Professor D. G. Christopherson. South Midland Education Discussion Circle. College of Technology, Gosta Green, Birmingham. Tues., Oct. 22, 7.15 p.m. (Tea 5.30 p.m.)
CHATHAM
Chairman's Address on "TACAN: A New Air Navigation System," by F. L. Fielding. London Graduate and Student Section. Medway College of Technology, Chatham. Thurs., Oct. 24, 7 p.m.
LIVERPOOL
"Brushless Variable-Speed Induction Motors," by Professor F. C. Williams, E. R. Laithwaite and L. S. Piggott. Mersey and North Wales Centre. Royal Institution, Colquitt-street, Liverpool. Mon., Oct. 21, 6.30 p.m.
NOTTINGHAM
"Mechanical Strength of Power Transformers in Service," by E. T. Norris. East Midland Centre. College of Arts and Crafts, Waverley-street, Nottingham. Tues., Oct. 22, 6.30 p.m.*
WEYMOUTH
"The Transatlantic Telephone Cable," by R. J. Halsey. Southern Centre. South Dorset Technical College, Weymouth. Fri., Oct. 25, 6.30 p.m.

Institution of Engineering Designers

LONDON
"Drawing, Imagery and Design," by P. J. Booker. Thurs., Oct. 24, 7 p.m.

Institution of Engineers-in-Charge

LONDON
Address by the President-elect, Sir Harold Roxbee Cox. Caxton Hall, off Victoria-street, S.W.1. Fri., Oct. 25, 6.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"The Strength and Stiffness of Scalloped Stiffeners Determined by Full-Scale Tests at Glengarnock," by K. V. Taylor and M. N. Parker. Tues., Oct. 22, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LIVERPOOL
Discussion on "Small Bore Pipe Heating." Liverpool Branch. College of Building, Clarence-street, Liverpool. Thurs., Oct. 24, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"Modern Battery Railcars," by Dr.-Ing. G. Wilke. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Oct. 23, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "Diagnosis of Causes of Ball and Roller Bearing Lubrication Failures." Lubrication Group. Thurs., Oct. 24, 6.45 p.m.*
"Dynamic Stresses in the Teeth of Spur Gears," by S. L. Harris. Meeting in conjunction with the Applied Mechanics Group. Fri., Oct. 25, 6 p.m.*
Discussion on "Is Britain Lagging in the Design of Small Cars?" and film display. London Graduates' Section. Tues., Oct. 22, 6.30 p.m.*
CARDIFF
Open Meeting. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Oct. 22, 6 p.m.
DERBY
"Some Problems in Lubrication of Small Two-Stroke Petrol Engines," by A. Towle. Derby A.D. Centre. Midland Hotel, Derby. Mon., Oct. 21, 7.15 p.m.
GLASGOW
Address by the Automobile Division Chairman. Scottish A.D. Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Oct. 21, 7.30 p.m.
PETERBOROUGH
"Applications of Radioisotopes to Engineering," by C. G. Clayton. East Midlands Branch. Conference Room, Central Electricity Authority's Generating Station, Peterborough. Wed., Oct. 23, 7.30 p.m.

Institution of Production Engineers

CARDIFF
"Management and Productivity," by W. E. Gowers. Cardiff Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Oct. 25, 7 p.m.
COVENTRY
"Russian Machine Tool Industry," by Norman Stubbs and Peter Trippe. Coventry Section. Craven Arms, High-street, Coventry. Mon., Oct. 21, 7.15 p.m.
WORCESTER
"High Speed Presswork," by J. A. Grainger. Worcester Section. Cadena Café, Worcester. Wed., Oct. 23, 7.30 p.m.

Institution of Works Managers

LONDON
Annual General Meeting at 7 p.m. "The Trade Unions and Productivity," by E. Fletcher, at 7.45 p.m. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 22.

Junior Institution of Engineers

LONDON
"Rocks and Sands," by S. J. Crispin. Fri., Oct. 25, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Brittle Fatigue," by G. M. Boyd. Engineers' Club, Albert-square, Manchester. Fri., Oct. 25, 6.45 p.m.

Non-Destructive Testing Society

LONDON
"Industrial Radiography with 5 mV Linear Accelerator," by R. Halmshaw. London and Home Counties Branch. 32 Welbeck-street, W.1. Fri., Oct. 25, 7 p.m.

Plastics Institute

LEEDS
"Materials Using Synthetic Fibres," by H. Wild. Yorkshire Section. Hotel Metropole, Leeds. Wed., Oct. 23, 7 p.m.

Royal Society of Health

YARMOUTH
"Post-War Rehousing in Great Yarmouth," by H. F. Dyson. Town Hall, Great Yarmouth. Fri., Oct. 25, 10.15 a.m.

Royal Statistical Society

GLASGOW
"Statistical Decision Theory," by Professor G. A. Barnard. Glasgow Industrial Applications Group. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Oct. 23, 7 p.m.
SHEFFIELD
"Different Methods of Introduction and Organisation of Quality Control in Manufacture Involving Complex Processes," by Dr. E. A. G. Knowles. Sheffield Industrial Applications Group. Y.M.C.A., 49 Fargate, Sheffield 1. Thurs., Oct. 24, 7 p.m.

Society of Chemical Industry

LONDON
"Accelerated Tests of Metal Coatings: Sulphur Dioxide Test," by J. Edwards, and "The Acetic Salt/Acid Spray," by J. H. Hooper. Corrosion Group. Mon., Oct. 21, 6.30 p.m.

Society of Instrument Technology

CARDIFF
"pH Measurement in Industry," by Dr. G. Mattock. South Wales Section. College of Technology, Cardiff. Wed., Oct. 23, 6.45 p.m.
GLASGOW
"Computer Control of Machine Tools," by A. A. Lodge. Scottish Section. Scottish Building Centre, 425 Sauchiehall-street, Glasgow. Fri., Oct. 25, 7.15 p.m.
MANCHESTER
"Interplanetary Instrumentation," by C. A. Cross. Manchester Section. College of Technology, Manchester. Mon., Oct. 21, 7.30 p.m.

South Wales Institute of Engineers

CARDIFF
Formal opening of the Institute's Centenary Celebrations. William Menelaus Memorial Lecture on "The Development of Britain's Physical and Geographical Advantages," by Sir Charles Goodeve. Tues., Oct. 29, 2.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineering Metrology Association, Northampton Polytechnic, St. John-street, London, E.C.1. (CLErkenwell 1662.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Packaging. Apply to Mr. H. Williams, 80 Lancaster-avenue, London, S.E.27. (GIPsy Hill 4859.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Works Managers, 196 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Non-Destructive Testing Society of Great Britain, 2 Tomswood-terrace, Barkingside, Essex. (Hainhault 4588.)
Plastics Institute, 6 Manville-place, London, W.1. (WELbeck 5439.)
Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. (SLOane 5134.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

The Human Element

Not Engels but Engel

Throughout the western hemisphere during the past 25 years a tremendous levelling out of wealth has been taking place. Capital no longer flows from a few hundred families. From industry's point of view this is of the greatest significance, and constitutes a new situation to which British industry has yet to adapt itself. The problem is the same in the United States, but there a large and continuous campaign has been under way now for some years to channel the small saver's money into industry. Why and how this is being done is a fascinating story, told in the September issue of *Optima*, the journal of the Anglo-American Corporation of South Africa, by Mr. Louis Engel, a partner in the American firm of stockbrokers Merrill Lynch, Pierce, Fenner and Beane. He is an expert in explaining the process of investment to the public and was for 10 years managing editor of *Business Week*. His is the largest firm of stockbrokers in the world, and was the first to attempt to draw in the small investor by commercial methods and advertising, on which they now spend 2 million dols. a year.

Engel's analysis of the reasons which prompted the firm's senior partner, Mr. Charles E. Merrill, to break with Wall Street tradition are valid throughout the capitalist world. Examining why the American stock exchange and industry are trying to stimulate public interest in investments, he writes: "The blunt fact of the matter is that they have no alternative. To-day, they cannot expect to sell millions of dollars' worth of stocks to hundreds of investors. They must, on the contrary, undertake to sell hundreds of dollars' worth of stock to millions of investors. And on their success—their continued success—hangs the whole future of American business, for only in this way, short of state socialism, will it be possible for industry to raise the new capital it will need for plant and equipment in the years ahead." American industry's requirements of new capital are now running at the rate of 38,000 million dols. a year; economists estimate that by 1965 they will exceed 65,000 million dols.

To sell industrial stock to what Engel calls "the new monied middle-class," described as families with incomes of 5,000 dols. a year or more, is industry's best hope of getting the capital it requires. Before the war there were 1½ million of them, now there are 19½ million; aggregate liquid assets have risen from 40,000 million dols. to 200,000 million dols. in 15 years. These are much greater increases than have taken place in prices and taxes. In time it will happen in Britain also, because it is a reflection of the growing managerial control of industry and of the vast growth in managerial ranks. Merrill's campaign made his firm the largest in the world; it also helped to raise the proportion of shareholding familes in the United States from 10 per cent. in 1952 to 13 per cent. in 1955. As Engel points out, much remains to be done, and techniques to be evolved, ignorance has to be removed, but the eventual result cannot be in doubt ; a people's capitalism is being born.

Satellite Roots

The Russians' preliminary conquest of space has set off a great deal of talk. Some of it has been focused on the roots of the Soviet lead, described by some as "supremacy." Last week, Dr. K. Mendelssohn wrote to *The Times* on the wider significance of the Russian achievement: "While we hope and believe that inter-continental nuclear war may never come, competition for the world's markets in industrial and consumer goods seem unavoidable and is probably not nearly so far off as most people believe." The launching of the satellite revealed a "general technical supremacy" which in Dr. Mendelssohn's opinion is the product of "a wise and far-sighted policy." It is wrong, he suggests, to decide that there shall be no sizeable expansion of technical education for five years.

Another letter on the same day was from Dr. Hewlett Johnson, Dean of Canterbury. He makes a good point, probably more basic than Dr. Mendelssohn's, although the Dean's irritating habit of denigrating almost everything British in order to extol everything Russian will (and already has) caused many people to miss it. He contrasts the quality of education in a public school and a grammar school (he is a governor of both) and goes on to say that far too small a proportion of boys and girls benefit from good quality teaching. Not enough is being done to arouse their interest in science and when "the great mass" leave school at the age of 15 few can know whether they have any aptitude. Much more, too, must be done to improve the quality of teaching in the early years. This is a most important point, and it is a great pity that most of the correspondents who reply spend more of their space attacking the Dean for his political bias.

Closing A Works

The recent difference of opinion between a Member of Parliament and the management of a large public company about the way in which news of a factory closing was passed on to the men, holds several warnings for industry in general and for those who comment on industrial troubles.

In the first instance, the real reason for the closure has much more to do with long-term technical change and consumer preferences than with the country's current economic difficulties. There is, therefore, no reason to suppose that the decision to shut down was a panic one or that it should be taken in any way as a case study for the present problem of defending the pound, with all that goes with it.

The second lesson is that if a large company is known for good industrial relations it stands to collect a disproportionately large share of adverse comment if it seems to have acted with lack of regard for the human situation. Large personnel departments must not only act humanely but must be seen to act humanely. A large machine must be kept well oiled as well as look impressively complicated.

Germany Calls in the Unions

The German Government has made it clear in the past that it considered the control of the broad issues of economic policy a matter for itself alone. Last month the idea received something of a jolt when the Ruhr coal and coke producers put up their prices without listening for the Government's views in the first place. Just before that the Government in a fit of mild authoritarianism told the unions not to interfere with public policy on price stabilisation, which was a matter for the State not for the unions. Things have how changed.

Last week the German Chancellor received a trade union delegation at Bonn after which a communique was issued saying that it had been agreed that prices must be kept stable. Dr. Adenauer has changed his views. The unions have been given a formal hearing. The reasons for the changed attitude lie in full employment and the growing fear of inflation. Germany has had less trouble than most countries of Western Europe in recent years about the level of prices in relation to wages, thanks to a reserve of unemployed which has been repeatedly reinforced from Eastern Germany. To-day, full employment has arrived and even the strongest economy in Western Europe has been forced to make the routine internal diplomatic moves to keep labour representatives informed and to ask for their co-operation. To judge from the experience of other countries there may be quite a high price to pay for their assistance in keeping prices down.

Attracting White-Collar Workers

When the new towns were originally planned, those responsible for working out the idea were impressed with the opportunity which the new townships provided for getting balanced communities established and of breaking down the old, bad tradition of the right and the wrong side of the railway line. White-collar workers were to live next door to the toiler with his hands and the old line of class distinction, so far as it was expressed in the better and the poorer ends of town, was to be banished. It has not worked out that way, partly because the operative has been found as little desirous of having white-collar workers next door as it was expected would be the feeling the other way round.

A new kind of problem of getting a balanced community has turned up at Corby, where a large Scots working-class population has become established over the years, mainly employed at Stewarts and Lloyds Limited. There has resulted what has been described as an intellectual vacuum which has, for example, prevented a company with a large number of young scientific workers from going into the neighbourhood. Here is a community, not seeking more industry and workers, but more intellectual material and presumably the white-collar standards which go with it. It is the town planners' problem in reverse. You start with the solution, by some standards, and have to work back to your problem. It is all very much of a nightmare for the tidy-minded.

Art Creates Quality

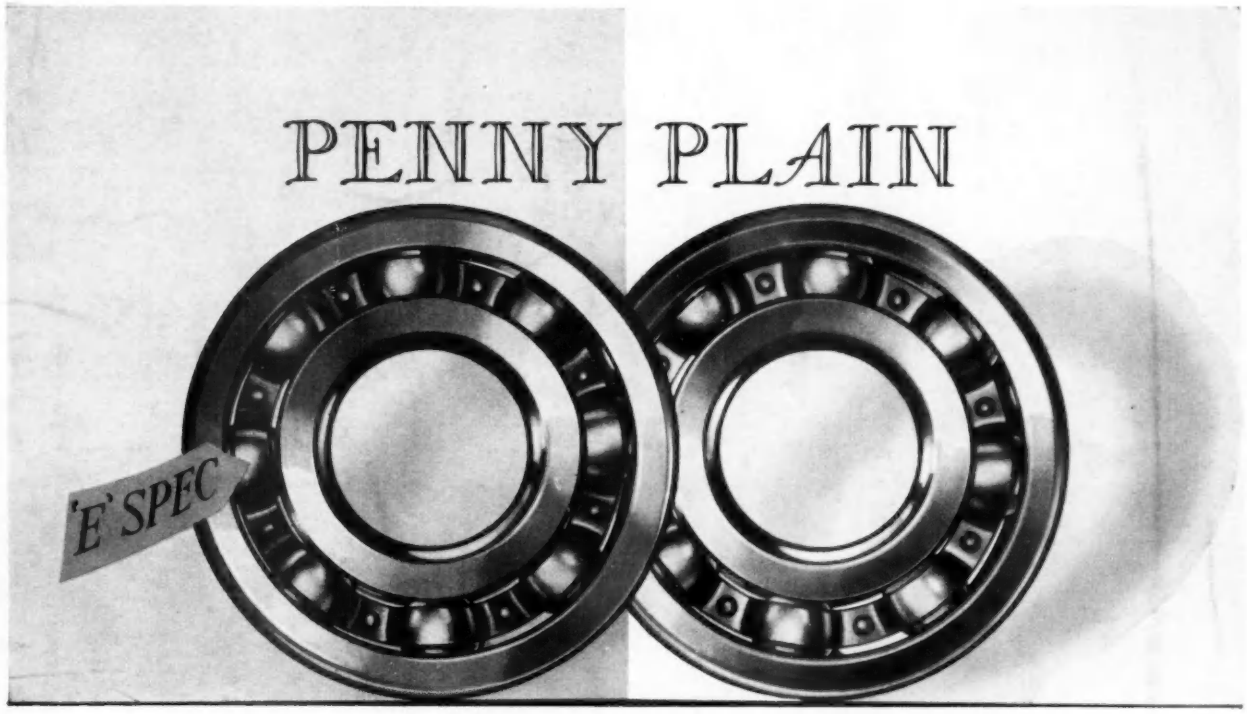
There is a tendency in post-war Britain to begrudge almost every item of public expenditure which cannot be convincingly labelled as utilitarian. That the Government should spend nearly £1 million a year on subsidies to the Arts Council of Great Britain sends certain organs of the Press in a wild frenzy of indignant protests.

Yet much more is needed if we are to go on having opera, ballet, music, drama, provided on a level which befits our dignity and spiritual wealth as a nation. In their 12th annual report, the Arts Council state that nearly every one of the 125 or so professional bodies to which they make grants are in "a chronic state of economic insecurity." In the past 12 months, two of the symphony orchestras have narrowly escaped dissolution; the two national opera houses are burdened with heavy overdrafts; theatres are closing all over the country; Carl Rosa is compelled to curtail its popular tours and to conduct its operations in hand-to-mouth fashion. The Royal Ballet and the Old Vic have to undertake prolonged dollar drives in America to make ends meet. Several provincial repertory companies are liable to restrict their activities.

This situation is not, according to the Arts Council, due to public indifference. Attendances are high and have not been affected by television. Most of the trouble is due to "an almost universal lack of working capital among the assisted companies." No national funds exist for their purpose, practically nothing has been spent since the war "on capital account" for the sake of the arts. The Royal Festival Hall and a new theatre provided by the City of Coventry, to be opened in the spring, are the only buildings of this kind built since the war. No action has been taken following Parliament's decision that a National Theatre should be built. This is a sorry tale, and reflects no credit on any of us. Art creates a taste for quality even in engineering design. Few to-day expect to buy their education in the market place.

ENGINEERING

An Illustrated Weekly Journal



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